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MACHINE DESIGN

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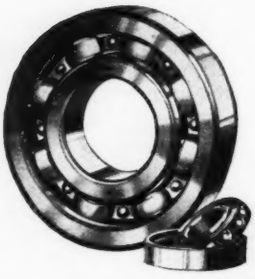
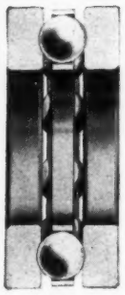
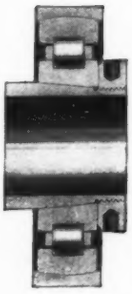
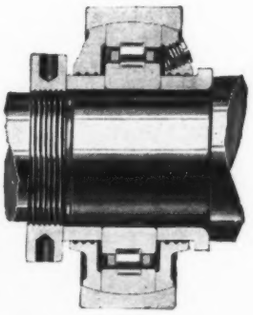
There is a PRECISION BEARING *for every* LOAD, SPEED *and* DUTY









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MACHINE DESIGN

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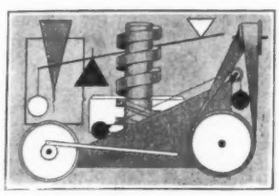
Volume 1 | **December, 1929** | **Number 4**



Next MONTH

AS USUAL, the National Power exposition coupled with the annual meeting of the American Society of Mechanical Engineers attracted hundreds of the design profession to New York, where the two events simultaneously took place early in December. New mechanical developments and their important role in industry were impressively shown.

Many identified with design were not fortunate enough to be able to attend. To these MACHINE DESIGN *in the January issue will bring the highlights of the exposition, particularly features pertinent to design. Thus you are assured of valuable information on the latest developments in this important field.*

L. E. Jermy.

Managing Editor

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MACHINE DESIGN
December 1929

You Cannot Afford to Ignore Style in Design

By L. E. Jermy
Managing Editor, Machine Design

DICTIONARIES define style as the "manner or conduct of action; characteristic of individual method; manner of form approved as elegant or fashionable; conformity to an approved standard; fashion; mode."

Until a few years ago, style was considered a factor only in wearing apparel, architecture, furniture, art, etc. Manufacturers of machinery gave it little if any attention. Seldom did it come within the purview of engineers and others charged with the design of machines.

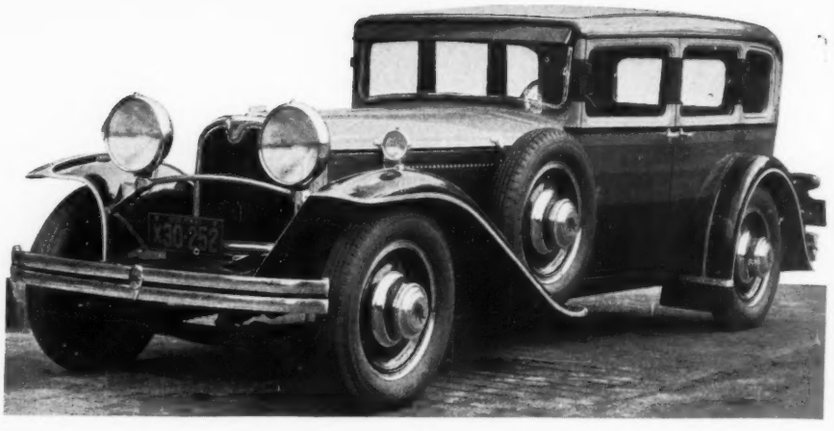
The events of the past decade have wrought great changes in the influence of style. The prevailing mode in any line of products has become an important factor in industry. Today every shift of public approval from one style to another sets up reverberations which may travel into industry's design department. Overnight an important invention may result in a new material, method or product that will make obsolete apparently firmly established designs of today.

For these reasons, engineers are beginning to realize that they cannot afford to ignore the influence of style. This is particularly true of those who contribute to the design of mechanical devices, the sale of which involves public tastes. Designers of automobiles, electric refrigerators, washing machines, home laundry appliances, etc., now are very much alive to the importance of style. In the early days of the development of these machines, utility took precedent over all other considerations. Today, however, problems of utility have been reduced to a routine and therefore the designer's greatest opportunity to create distinctiveness lies, in most cases, in his treatment of the esthetics of his product.

This is not predicted on the thought that beauty is skin deep, or on the belief that good appearance alone will create a demand for a machine product. Apparently the prevailing design policy in the case of automobiles and mechanical household appliances is that a machine that is good mechanically and in addition possesses an attractive appearance will be more

THREE forms of transportation, pictured here, and all within the span of a lifetime! Such is the rapid pace of progress today. To sense the changes in mode, to evaluate their importance and to judge their influence on design are new obligations of the progressive engineer. He cannot afford to ignore them.

NOTE the contrast between the cars of 1904 *and* 1929. *Each is representative of the best in its day. The White of* 1904 *was designed primarily for utility; the Ruxton of* 1930 *for appearance and style, as well as utility.*



popular than one of equal mechanical perfection which lacks distinctive beauty. In other words, utility and style make a winning combination.

Indicative of the emphasis placed on these twin factors in the automobile industry is the advertising of the 1930 model Hupmobiles, now appearing in the national magazines. The advertisements in which the new cars were announced were devoted almost entirely to style. The new model was introduced as "The car of *harmonized beauty.*" Here are a few of the appealing phrases employed:

"100 horsepower and 80 miles per hour *sheathed in the smartness of an original decorative idea.*"

"The first motor car ever designed to carry a single *style motif* inside . . . outside . . . throughout the car."

"Never before has a single decorative design been used to create a *perfect and harmonious ensemble,* inside and out."

"This new Hupmobile is planned to harmonize in a *single chord of beauty.*"

The text is accompanied by drawings showing the design motif applied to radiator, hub caps, steering wheel, instrument panel, radiator cap, door handles, fender parking lights, door molding, bumpers, smoking set, etc.

Then in later issues, appeared advertisements extolling the mechanical virtues of the car. The sequence of the appeals, however, shows that the Hupp Motor Car Corp. is banking heavily on style and beauty in its 1930 program.

Another good example of how utility and style are combined to entice the prospective purchaser is furnished by the "Voss Vanity" washing machines. The current model is being advertised to bring out three distinctive points: 1. An exclusive floating agitator; 2. Beauty . . . "its trim graceful lines meet the *modern demand for beauty* . . ."; 3. It may be changed from a washer to an ironer by means of a special attachment.

Thus the Voss Bros. Mfg. Co.—manufacturer of washing machines for 54 years—today finds it desirable to emphasize the esthetic as well as the mechanical advantages of its products.

Other instances might be cited to show how manufacturers of sewing machines, computing machines, typewriters, refrigerators, vacuum cleaners and numerous other articles are emphasizing appearance, but the two mentioned are sufficient to indicate the ascendency of style as a factor in design.

What About Style in Industrial Machinery?

At this point, the skeptic will say "Yes, you are right. Style is important in these machines that are purchased by women or by men for personal or household use. But what about machines for industrial use? As a designer of machine tools, for instance, why should I be interested in style?"

Industrial machinery, of course, is purchased more for performance than for appearance, but it is a serious error to assume that the influence of style is negligible. There are established standards of fashion in locomotives, cranes, machine tools, tractors, agricultural equipment, conveyors, etc., just as in the case of household mechanical appliances. This style, however, lies more in mechanical details than in beauty and appearance.

Take the item of ball and roller bearings as an example. Recently an engineer who has designed many machine tools declared that frequently he has found it desirable to specify antifriction bearings for certain rotating shafts, not because the conditions of operation warrant their use but because users of the machine demand them. In other words, antifriction bearings are distinctly modish in certain types of machinery, and engineers must consider this fact along with the strictly technical aspects of design.

Strong Talking Points in Selling

Numerous other parts and accessories have become forceful talking points for the sale of machines. Among these are lubricating systems, machine-cut gears, certain parts of alloy steel, and motors integral with the machines. In working out the design of a new model, the engineer is obliged to weigh the various available materials, parts and methods not only in the light of mechanical fitness, but also in regard to the attitude of purchasers toward these features. And thus, while he may not realize it, he is dealing with the influence of style—style as represented by the users' preference for advertised accessories.

Perhaps the most important aspect of style in industrial machinery is the universal acceptance of a machine that is good mechanically and whose appearance connotes expert workmanship. The most efficient machine ever built will suffer a serious sales handicap if it has the appearance of being carelessly designed. A clumsily placed pulley or gear, which looks as if it had been put on as an afterthought, may give the prospective purchaser the idea that the entire job is characterized by slipshod engineering.

That the Reeves Pulley Co., Columbus, Ind., recognizes this trait in human psychology is indicated by the following communication from R. F. Reeves, secretary of the company:

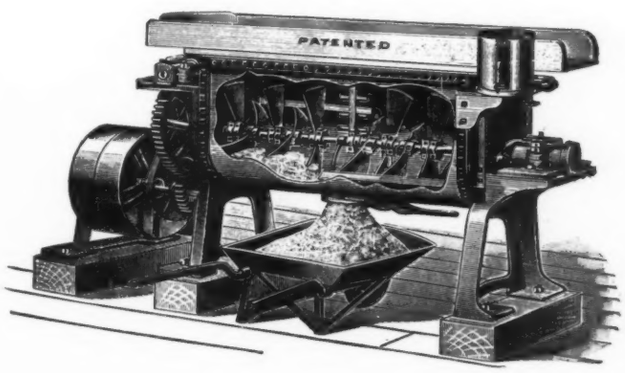
"In designing the new and modern type Reeves variable speed transmission it was natural that our engineering department should give predominance to the matter of securing the utmost mechanical efficiency and also to design a unit which would represent the most compact construction possible.

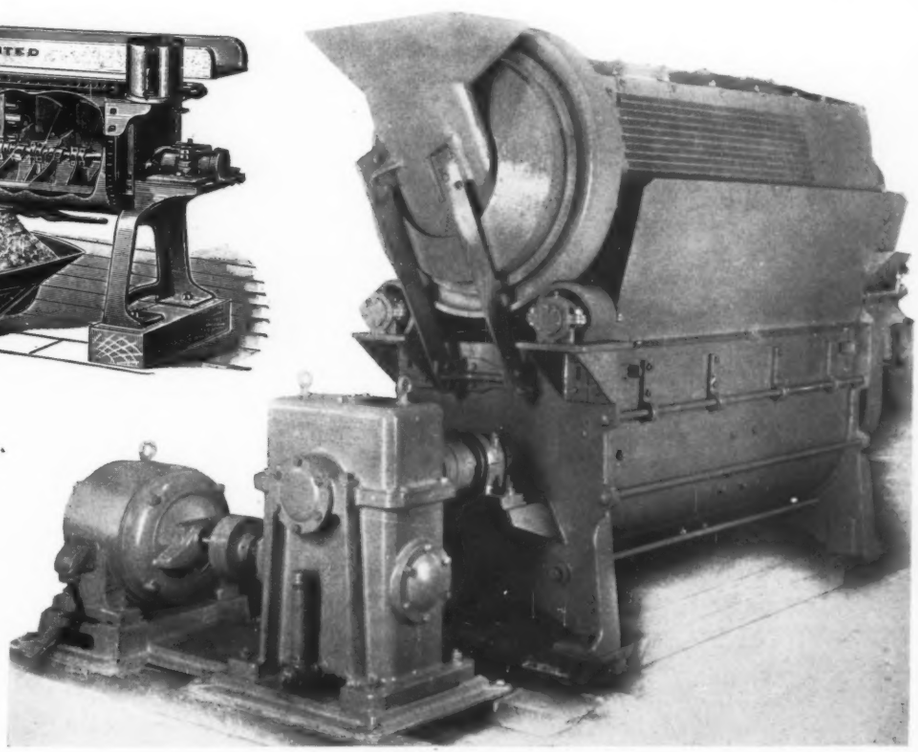
"The matter of securing the most compact construction is synonymous, to a certain extent, with an unmistakable appearance of efficiency and durability.

"In other words, it is natural to associate the idea of efficiency with that of a neat and durable appearance and we believe it has become recognized, with reference to mechanical equipment, that a unit which presents a neat appearance and an excellent finish also denotes a high degree of workmanship and of mechanical efficiency.

"For this reason it is our opinion that close attention should be paid to the matter of appearance and that it is rarely necessary to sacrifice neat and attractive appearance of any machine or unit for durability or efficiency but, to the contrary, that these factors in the design of any piece of mechanical equipment are closely linked together."

Many other manufacturers subscribe to the idea that there is a close relationship between





TWO Standard sand mixing machines, models of 1904 *and* 1929. *The changes in* 25 *years are increased efficiency and improved outward appearance, which connotes better design.*

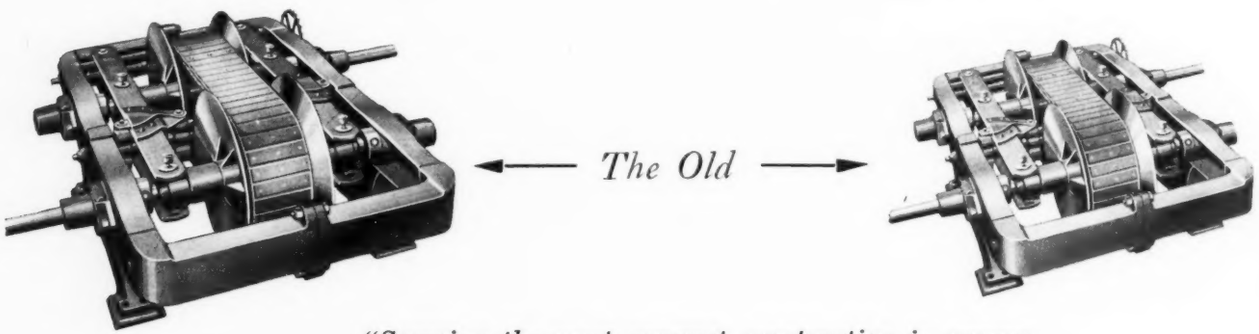
good mechanical design and outward appearance. The Standard Sand & Machine Co., Cleveland, builder of sand mixing machinery, has constantly improved its product from the standpoint of mechanical efficiency, and in doing so has found that each new model "looks more efficient." In contrasting the models of 1904 and 1929 illustrated on page 11, the reader can readily understand the proud assertion of Harry E. Boughton president of the company, that "We have made a Packard of our latest sand mixer."

Among the design changes in recent models is a totally enclosed gearbox driven directly from an enclosed type motor. Roller bearings in housings of special construction are used on all the important bearings of the machine. These roller bearings are protected thoroughly by the construction of the mountings and caps, and also by a special form of sealer employed to eliminate the possibility of sand creeping to the bearing along the shaft. All important surfaces are machined, including particularly the trunnion tire and rollers. The steel roller chain employed for driving the screen is well protected. These and other refinements have served to make the machine more fitted for the conditions under which it works, and also have effected a savings of 30 to 50 per cent of the amount of power consumed.

If it were possible to trace the motives for each change in the sand machines from 1904 to 1929 and to compare them with the influences which prompted the various steps in development from the automobile of 1904 to that of 1929, we would find a striking similarity. In both early models working parts were more or less exposed to view. Somewhere in that span of 25 years it became the mode to enclose gears, shafts, etc.

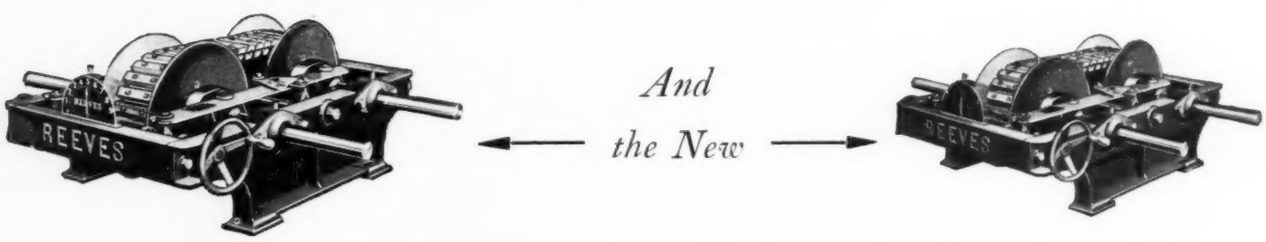
That all machinery passes through this period of style change is the opinion of Dr. W. Kummer, engineer, Zurich, Switzerland, who writes in *Schweizerische Bauzeitung* (April 7, 1928):

"In the early stages of development, the working mechanisms of the machine were exposed insofar as this was possible, to disappear later more and more inside of closed housings. This transition from the 'unclad to the clad' is based first on technical reasons. It was necessary as long as they did not prove dependable to watch over the sensitive parts and leave them readily accessible. With increasing experience higher speeds were ventured, which as a matter of course required enclosed structures.



The Old

"Securing the most compact construction is synonymous . . . with an unmistakable appearance of efficiency and durability."—SEE TEXT, PAGE 11.



And the New

"Where one still finds a pronounced open type of machine construction, it is either a matter of antiquated slow-running types of large radial dimensions, or of elements whose operating safety is still a matter of doubt."

At one time it was considered proper to design a machine and then after it had been completed to bolt legs to it to give it the desired height. Awkward legs were much in evidence in that period. Today the legs have disappeared in most machines, the frame having been designed to give the entire unit a harmonious appearance. The same idea holds good for all attachments. The modern policy calls for design that makes every part seem to belong to the whole.

These are only a few of the many points of style that could be cited. The profession of machine design is in need of more definite information on the subject of "Esthetics in Machinery," and it is hoped that this brief introduction may be the means of stimulating discussion of that topic in the columns of this magazine.

Scanning the Field for Ideas

A Monthly Review of New Machinery, Metals and Parts, with Special Attention to Significant Design Features and Trends

New Airplane Design Is Noteworthy—Use Stacked Disks as Springs—Rubber As a Bearing Material—Designing Riveters for Versatility — Load-Carrying Locomotives

DEVELOPMENTS in the field of aeronautical engineering are approaching a most interesting stage. Most of the primary problems of mechanical flight have been solved. The utility and durability of heavier-than-air machines have been demonstrated. From now on more attention will be paid to refinements that will result in higher speeds, increased flying radius, greater lifting power and efficency.

Whatever is achieved by aeronautical engineers during this period of refinement should be worthy of the attention of engineers in every branch of the machinery industries. We may confidently expect to learn much from them regarding the cooling of internal combustion engines; the use of light, strong structural materials; reduction of air friction on moving vehicles; and many other points of wide application.

Already we are beginning to witness revolutionary developments in airplane design. The plane shown in Fig. 1 is said to be so radical that it was necessary to resort to basic principles in carrying out the design of almost every part of the structure. The machine is a Bellanca Tandem, constructed to the design of Guiseppe M. Bellanca, president of the Bellanca Aircraft Corp. New Castle, Del., and is intended for use in a projected endurance flight.

Engines Are Mounted in Tandem

A feature of the plane lies in the attempt to derive lift from all major units and at the same time to reduce, particularly for a dual engined plane, the frontal area. The latter is effected by mounting the engines (two Pratt & Whitney, 400-horsepower, Wasp type) in tandem back to back, as closely as possible, and enclosing them in a cowling of cylindrical shape which forms the nose of the machine. The rear engine has a driveshaft approximately 4 inches in diameter which passes through the fuselage to a point at the rear where a 3-blade steel pusher propeller is mounted. This driveshaft, running on self-aligning bearings, is housed in a casing of duralumin, a material much to the fore in airplane

Fig. 1—The new Bellanca Tandem plane is revolutionary in design

HOW MACHINE DESIGNERS ARE MEETING

ADAPTATION of methods, materials and parts in machines to the constantly changing demands of industry furnishes a continuous panorama of engineering achievement. The illustrations presented on these pages indicate the important role of design in today's progress in five widely diversified branches of industry.

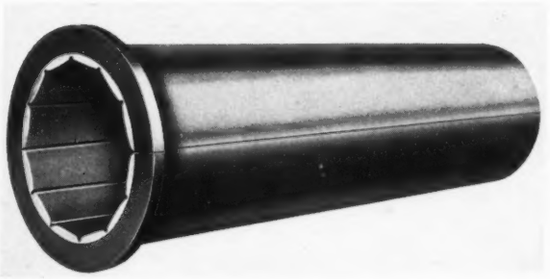


Fig. 3—Rubber bearing for propeller shaft

RUBBER has become an important product in machinery; in fact, the term "mechanical rubber goods" is well known. The use of rubber for bearings for propeller shafts seems new. The bushing shown above and in Fig. 9, is discussed on page 16. It has been employed where lignum vitae previously was used.

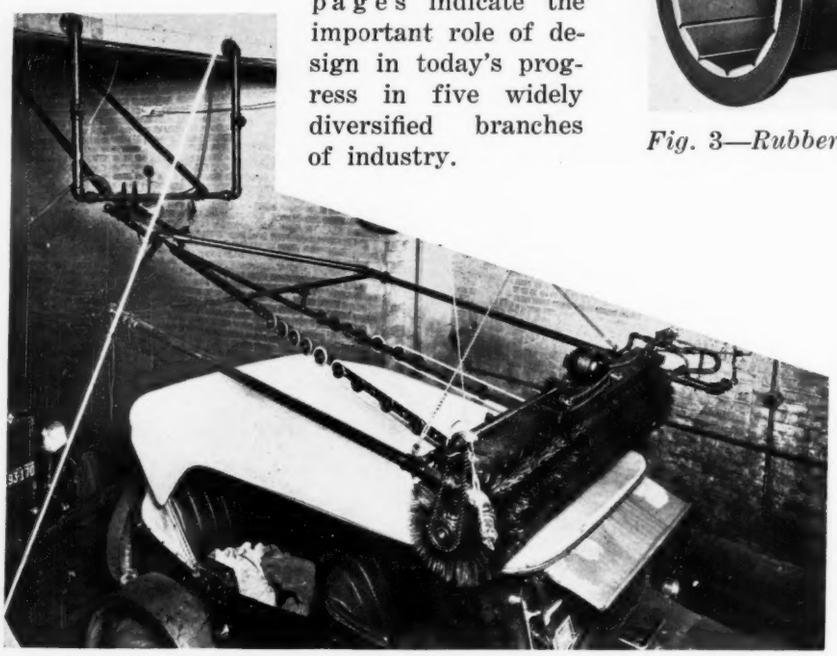


Fig. 2—A sweeper-like device for cleaning the tops of automobiles

WASHING automobiles in sufficient numbers to justify mass operation methods is responsible for the device illustrated above in Fig. 2, and which is described on page 16. The designer probably developed this machine from the modern street sweeping apparatus, but he also added a number of original features, as will be seen from the text.

PLASTIC materials such as bakelite are so widely used today that improved methods for forming them are necessary. The press shown in Fig. 4 is the machine designer's response to this new need. It has many features in common with modern metal molding machines. It forms 49 telephone mouthpieces at one time.

Fig. 4—Mold press for making mouthpieces for telephones

THE NEW REQUIREMENTS OF INDUSTRY

DRIVING of large rivets in the field sometimes presents considerable difficulty, as in the case of this 18-foot penstock of a 70,000-horsepower hydraulic turbine at Niagara Falls. The plates are 1½-inch thick and the rivets 1½-inch in diameter. The method of suspending the 150-ton riveter, built by the Hanna Engineering Works, Chicago, is illustrated clearly in Fig. 7. The riveter frame may be tilted up or down 30 degrees from the horizontal and may be rotated. Two 2-horsepower air drill motors drive the tilting and rotating mechanism. The use of anti-friction bearings reduces the power required for rotating the frame.

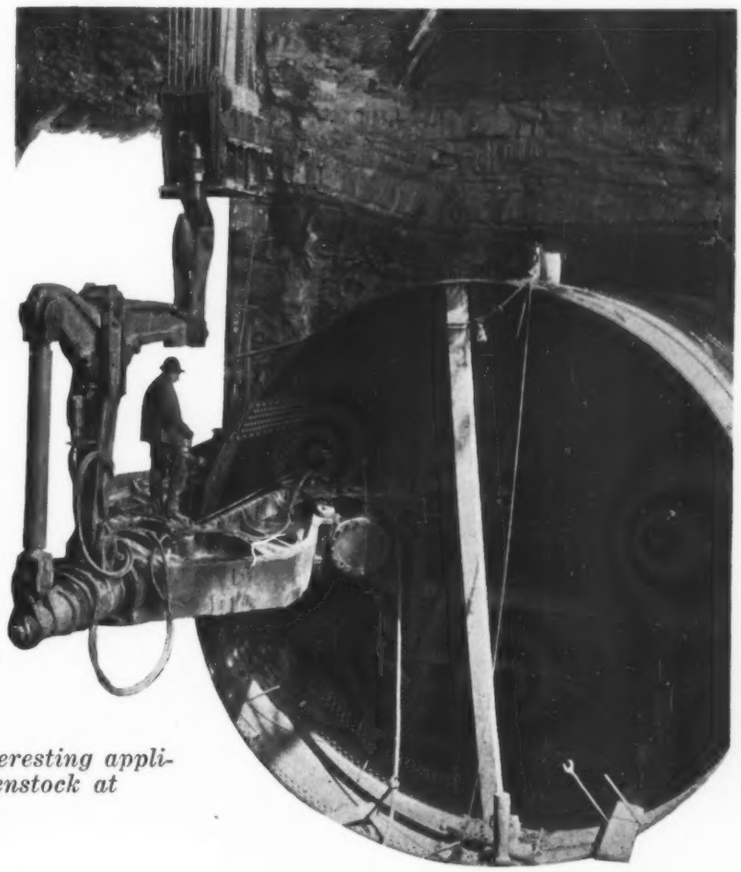
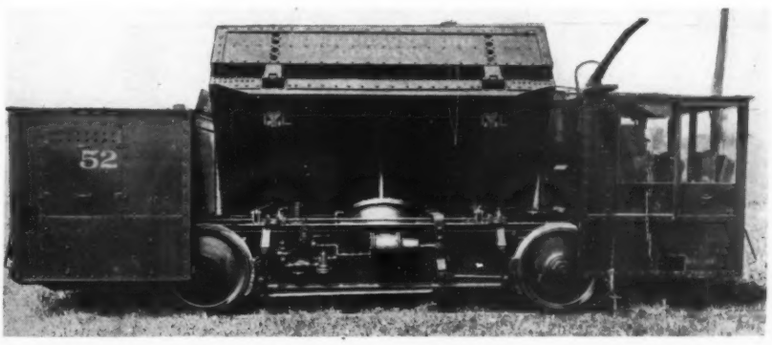


Fig. 7 (upper right)—An interesting application of a riveter on penstock at Niagara Falls



Figs. 5 and 6—Electric locomotive for iron ore mines

THE ore train shown below travels loaded from the mine and returns empty. By using locomotives of the type shown in Figs. 5 and 6, the Susquehanna Ore Co. utilizes the weight of ore on the locomotive to give added traction. Otherwise, locomotives of much greater weight would be required.

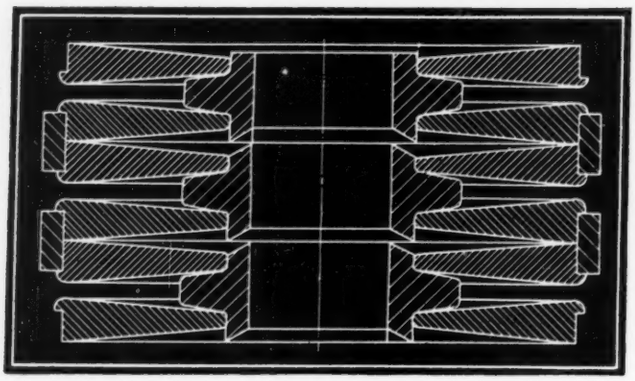


Fig. 8—Cross section of a stack of tapered disk springs

construction. Obviously, in the form of engine mounting described there is apt to be some difficulty in connection with the cooling of the rear engine. It is understood, however, that the cowling is fitted with deflectors to obviate this.

As an offset to the minor difficulties which, if not already overcome fully, undoubtedly will be, the mounting of the engines in tandem has the additional advantage that if one engine fails, the dead engine does not offer wind resistance, nor does it have the same effect as a wing engine failure on the maneuverability of the craft.

It is especially interesting to note that in this plane the mounting of the engines and other heavy members of the craft is such that no load is placed behind the pilot; thus, in the event of a crash the danger is reduced to a minimum.

Washes Auto-Tops Automatically

A NOVEL car-top washer which, while just as efficient as hand labor, can be operated at one-thirtieth of the cost, is shown in Fig. 2. It is the only automatic machine of its kind in existence and it is in exclusive use by Super-Service Stations, Inc., 333 North Michigan Ave., Chicago. The machine is covered by patent applications.

The revolving brush used on this machine is not of the ordinary fibre type but is of selected hog bristles which will not damage the finish of the cars being cleaned. It revolves only when a car passes under it, the framework being provided with a series of rubber rollers which serve to lift the brush to the top level of the car traveling beneath, and at the same time to start the ¼-horsepower motor which is geared to the brush. Jets of water pass through the brush as it revolves. Immediately the car has passed, all mechanism automatically shuts off until such time as the next car in line again raises the rollers and starts the machine.

It may be said that the operation of this washer is similar in many respects to that of a road sweeper. Assuming that it is, this is another example of the application of ideas embodied in a machine used in another field.

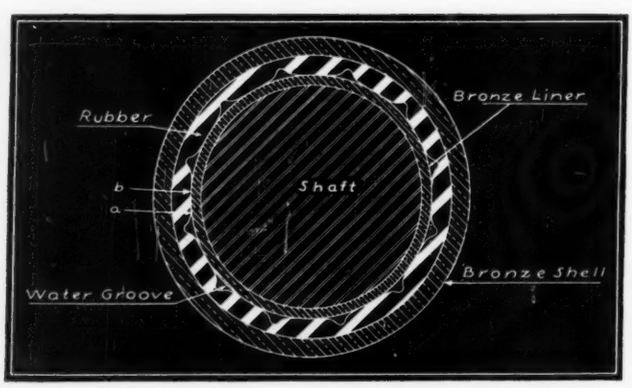


Fig. 9—Cross section of rubber bearing for propeller shaft

Rubber As a Bearing Material

ANOTHER machine part around which much interest centers is the rubber bearing manufactured by the B. F. Goodrich Rubber Co., Akron, O. This product is illustrated in Fig. 3 and a cross section is presented in Fig. 9. The bearing shown was developed for use in the stern tube of steamships, through which the propeller shaft passes. Heretofore this bearing usually had been lined with lignum vitae, but it seems that such good service has been obtained from the rubber bushing that it may supplant the wood liner construction. The rubber is of the consistency of a good automobile tire tread. It might seem that it would be altogether inadequate for the service, but when it is realized that rubber stands up under the terrific wear it receives as a tire, as compared with steel skid chains which are ground through in few hundred miles, and also that the coefficient of friction of wet rubber on metal (as a rubber heel on a manhole cover) is very small, its practibility becomes more apparent.

The bearing is similar to the standard segmental lignum vitae bearing in that it presents a number of faces to support the shaft, these faces being separated by longitudinal grooves for the passage of lubricating water. The faces are rounded, as shown in Fig. 9, to take advantage of the resiliency of the rubber. The load thus varies from zero at *a* to a maximum at *b*, and this allows the lubricating film of water to form at a point of low pressure. The film is then dragged by its adhesion to the shaft through the length of the face. Once formed, the film is not destroyed readily, provided the shaft speed does not fall below a critical speed.

It is said that in sandy water the rubber bear-

ing stands up remarkably well, any particles of sand entering being depressed into the rubber and then rolled into the grooves. Because of the rolling instead of dragging action the shaft assumes a high polish, in contrast to the scored appearance which it assumes with a hard surface bearing.

Press Molds Plastic Materials

THE mold press illustrated in Fig. 4 was developed by engineers of the Western Electric Co. under the direction of W. G. Altpeter and D. V. Waters, and is now being handled by Busch-Sulzer Bros., St. Louis. It is equipped, in the illustration, for molding the mouthpieces of telephone transmitters and is capable of producing these at a speed of 49 per minute. The machine not only incorporates a main hydraulic ram for raising the lower platen, but also a hydraulically operated subpress which is used during cooling, and for closing and stripping the molds. The tilting head seen in the illustration also is hydraulically operated, as are the pull-backs for lowering the platen.

Suggests Springs of Stacked Disks

ARE we facing the possibility of the introduction and widespread use of a new type of spring? This question arises through the fact that radially tapered disk springs, a series of which is shown in Fig. 8, appear to have many advantages. These were discussed in a paper prepared by W. A. Brecht and A. M. Wahl for the recent general meeting of the American Society of Mechanical Engineers. It is explained that the radially tapered disk spring often can be substituted for the helical spring where loads are high and deflections relatively small. In these cases the advantages of the disk spring seem to be: (1) It is adjustable in height and flexibility by taking off or adding disks; (2) will withstand lateral as well as axial loading; (3) can be designed so that no disk will be overloaded, and failure of one disk will not cause complete loss of flexibility; (4) large helical springs are more difficult to heat treat uniformly; (5) disk springs can be designed to occupy little space in the direction of load application.

Obviously the disk spring would be more expensive to manufacture than a helical spring; to an extent, however, this would be obviated where production was sufficiently high to warrant making forging dies. Tapered disk springs have been successfully die forged from 0.90 to 1 carbon spring steel so that no machining was required on the faces.

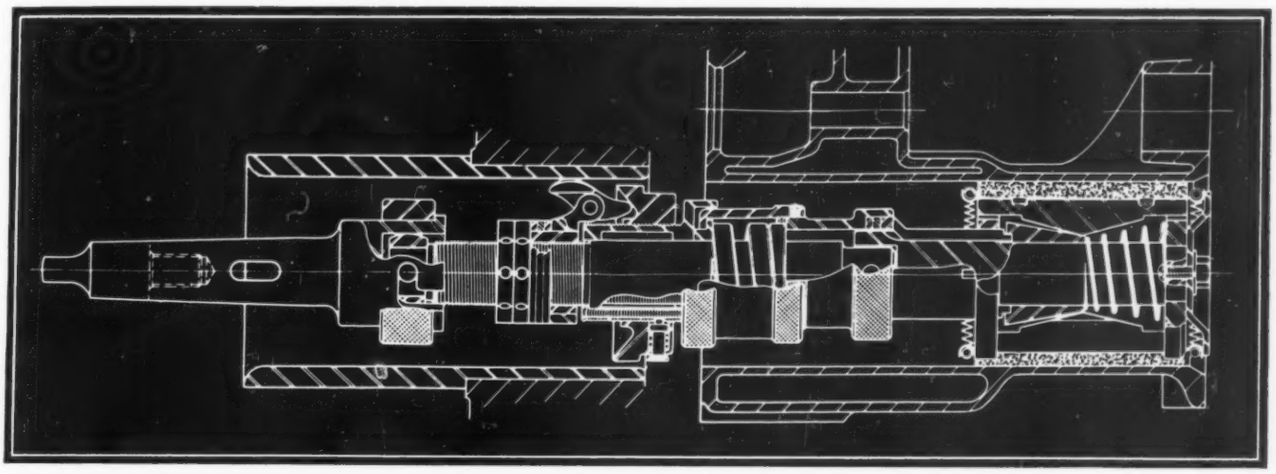


Fig. 10—*Sectional drawing of micromatic hone for accurate internal work*

Cylinder Hone Is Automatic

FOR finishing automotive engine cylinder bores by the honing process, the Micromatic Hone Corp., Detroit, recently perfected a new micromatic cylinder hone embodying a new principle. Construction details are shown in Fig. 10. Automatic in action, the new unit eliminates a hand-expanding operation and is essentially a high-production tool.

A hardened and ground bushing is mounted directly above the cylinder bore. This bushing operates the expansion mechanism, controls size and acts as a guide for the hone while entering and leaving the cylinder bore. Abrasive members are rotated and reciprocated in the bore a given number of strokes. When the operation is completed a throwout attachment automatically raises the honing tools out of the bore.

Cam Design from the Standpoint of Stress Analysis

By John Flodin

Assistant Professor Machine Design, University of Minnesota

CHIEF engineers, designers and others especially interested in cam design will recall the article "Practical Suggestions for Laying Out Cams," which was included in our October issue and covered the methods employed in designing cam outlines. In the accompanying article, which forms a fitting sequel, the author goes a step further and treats the subject technically from standpoint of force analysis.

IN DESIGNING cams the first concern of the designer is to delineate the cam outline so that it will give the required motion to the follower, perhaps modifying the follower motion to obtain a smoother working mechanism. The method for designing cam outlines was described by Mr. F. B. Jacobs in the October issue of MACHINE DESIGN.

The movement of the follower is not, however, the only consideration to be borne in mind, the force to be transmitted often being of major importance. But, except in slow speed cams, the force cannot be considered as entirely divorced from the nature of the follower movement, because an incorrectly laid out movement may cause heavy acceleration stresses.

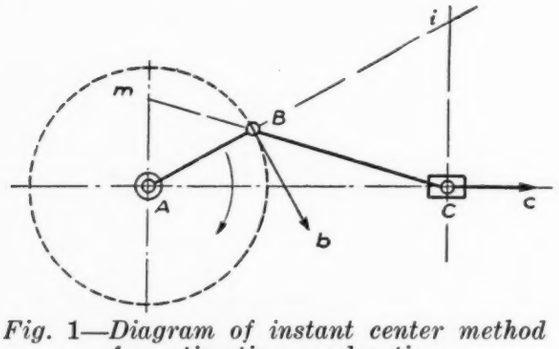


Fig. 1—Diagram of instant center method for estimating acceleration

If the cam chart or displacement diagram has been laid out to give the details of the follower movement and not merely to indicate, so to speak, the departure and arrival of the follower at important stations, then the smoothness of the chart curve will give an index of the smoothness of operation of the cam, and maximum smoothness of operation means minimum acceleration

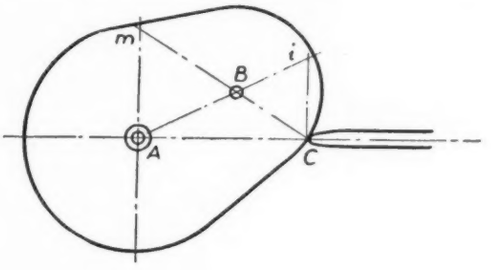


Fig. 2—Instant center method for acceleration, with point type follower

stresses. The actual acceleration can best be estimated from the cam itself, and for this purpose the instant center method seems the most convenient.

To make clear the reasoning which will be set down later, we shall first review briefly the meaning of the instant center. In Fig. 1, *AB* is a crank centered at *A*, *BC* is a connecting rod, and *C* a slider traveling in guides. Let *AB* turn in the clockwise direction, and let *Bb* be the tangential velocity of *B*. *Bb* is then merely a vectorial representation of the circular velocity of *B*, which is known from the rotative speed of the crank and from the length of the radius *AB*. Once this velocity is established, the magnitude and direction of *Bb* is fixed and is independent of the location of the center of rotation, provided that the center of rotation is on the line *AB*, or on *AB* produced, so that *Bb* is at right angles to the radius drawn from the center of rotation, which makes *Bb* tangent to the path of *B*.

The movement of *C* is along a straight line path fixed by the guides, so that we may say that *C* moves about a center of rotation at infinity, on a line drawn through *C* and perpendicular to the

path of C. But the center of movement of C may be regarded as being anywhere on the normal through C, the actual path of C being circular when the radius becomes finite, while the straight line vector Cc remains unchanged, Cc being the tangent to the actual path of C.

Are Points on the Connecting Rod

Now both B and C are points on the connecting rod BC, which is fixed both as to location and movement by the location and movement of the two points. Hence the intersection of the perpendicular to Bb and the perpendicular to Cc is a point about which the rod may be regarded as moving at the instant when the mechanism is in the position shown. This is the instant center and is indicated by i in the figure.

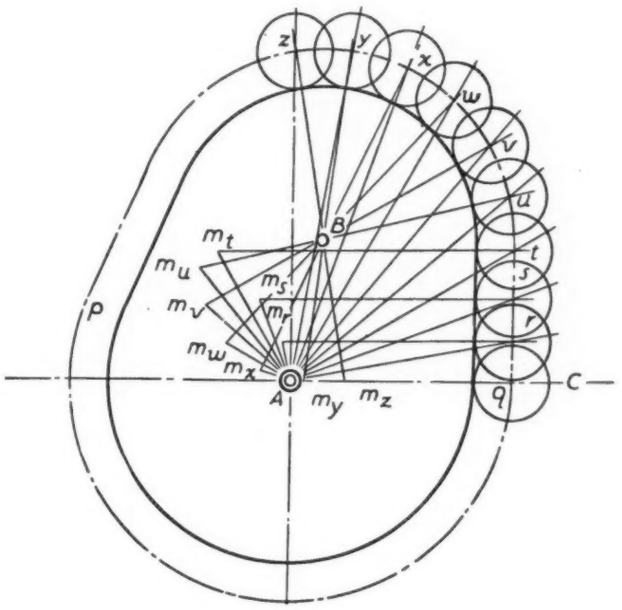


Fig. 3—Application of system shown in Figs. 1 and 2, with roller type follower

To make the significance of this point clear, lay a piece of tracing paper over the figure, trace off the triangle BCi, pin the paper to the page at i, and cause it to oscillate through a small angle about i. It will be seen that C describes an arc tangent to Cc, and that B describes an arc tangent to Bb. The ratio of the velocity of C to that of B is therefore equal to the ratio of the corresponding radii from the instant center, or

$$\frac{Cc}{Bb} = \frac{iC}{iB}$$

If we produce BC until it intersects the vertical through A, so that we get point m, we have triangle ABm similar to triangle iBC, so that

$$\frac{Cc}{Bb} = \frac{iC}{iB} = \frac{Am}{AB}$$

Then, if the motion of the crank AB is uniform, Bb is constant ($= 2\pi\ AB \times N$, N being the number of revolutions per unit time), and we may select the scale for the velocity vectors such that the length Bb is equal to AB. The velocity of C then becomes equal to Am, to scale.

This system we may now apply to the tangential cam shown in Fig. 2. A is the center of rotation of the cam, and B is the center of curvature of the toe of the cam. C is the follower which has been shown of the "point" type, for simplicity. It travels in a straight line path exactly like slider C in Fig. 1. AB acts like a crank and is the counterpart of AB in Fig. 1, and BC becomes the connecting rod. The velocity of C is therefore measurable by the magnitude of the intercept Am, provided the scale is so selected that the length AB represents the velocity of B.

The application of this reasoning will be shown more fully for the cam in Fig. 3, with a roller follower. The lower part of the cam, between p and q, is an arc of a circle whose center is at the center of rotation of the cam, so that this part gives no motion to the follower. But motion begins as soon as q passes below AC, so that when the cam is in the position shown acceleration of the follower is about to begin.

Now the follower path upward from q and to a point about midway between t and u is a straight line, which is an arc of infinite radius. Therefore the radius of curvature, which corresponds to the connecting rod of Fig. 1, is drawn perpendicular to line qt through the follower position, no matter where along the straight line the follower may be. When the cam is in the position shown, the radius of curvature coincides with Aq, giving no intercept on the vertical and therefore zero velocity of the follower. But if the cam is turned through a ten degree angle, the follower will have moved and will have attained a definite velocity.

Turn Follower Instead of Cam

Instead of turning the cam it is much more convenient to imagine the follower as moving upward with reference to the cam, so that the roller center successively occupies the positions r, s, t, etc. Drawing in the radii of curvature

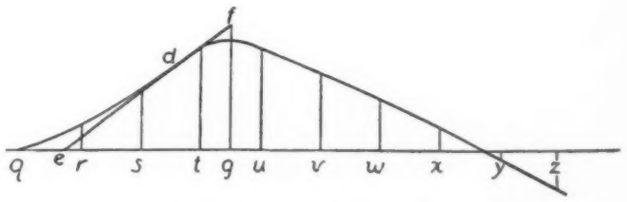


Fig. 4—Velocity diagram for cam shown in Fig 3, drawn to reduced scale

perpendicular to the roller path through each of these points, and erecting perpendiculars through the center of rotation A to the radiants Ar, As, at At, gives the successive intercepts Am_r, Am_s, and Am_t, which represent the velocities of the follower for the respective cam positions.

When the follower roller has reached point u, the path has changed from a straight line to an arc with center of curvature at B. To get the

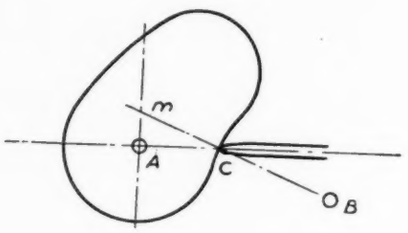


Fig. 5—Case in which center of curvature is outside cam

intercepts we therefore draw the connecting rod lines through B and u, B and w, etc. Perpendiculars to radiants Au, Av, etc. are again drawn through A, giving intercepts Am_u, Am_v, etc.

While the cam has turned through any angular interval, a definite length of time has passed. If we lay off the time intervals represented by the motions from q to r, from r to s, etc., along a horizontal axis, as in Fig. 4, and erect normals equal in height to the corresponding Am intercepts, we get the velocity curve shown. It should be remembered that the distances qr, rs, st, etc. represent time, not space. If the velocity of the cam is constant and if the angular intervals have been made equal, then the distances between the ordinates will be uniform.

Acceleration, which is what we seek, is the second derivative of space with respect to time, or the first derivative of velocity. Graphically this means that if we wish to find the acceleration at any point d on the velocity curve shown in Fig. 4, we draw a tangent to the curve through that point. The tangent intersects the base line at e. If we erect any convenient perpendicular, as gf, then the ratio gf to eg is the required acceleration, both gf and eg being in their proper units. This ratio is maximum when the angle feg is maximum, so that we can easily select the point on the curve at which the acceleration is most significant.

The force necessary to produce acceleration is expressed by the familiar formula, $F = ma$, where F is the force in pounds, a the acceleration as found from the graph, and m the mass, for which we must substitute $W/32.2$, W being the resistance offered by the follower, in pounds. Note that 32.2 is the gravity constant in feet *per second*. If this constant is to be used without modification the acceleration must be expressed in feet per second per second, and it is well to bear this in mind when the velocity graph is laid out.

In Fig. 4 the analysis has been carried considerably farther than ordinarily would be necessary, the purpose being to show the ease with which we may step from one cam curvature to another. In practice, only the maximum acceleration is significant, or the acceleration at the point where the sum of the follower resistance and the acceleration force is maximum. It is usually possible to determine by inspection a fairly narrow range of follower movement for which it is necessary to analyse the acceleration, and to draw only a short velocity curve covering this range. Four or five ordinates for the velocity graph are enough for this purpose.

That this method is equally applicable when the center of curvature falls outside of the cam is shown by Fig. 5. A is again the center of rotation of the cam, B is the center of curvature, and C is the point of contact between the follower and the cam face, or the center of the roller, if a roller follower is used. CB thus becomes the equivalent of the connecting rod of Fig. 1, which, when produced, gives m, the intercept Am being the velocity, as before. The instant center is at the intersection of a line connecting A and B and the perdendicular to AC through C.

It is easy to show that this method is equally valid when the center line of follower travel does not pass through the center of rotation of the cam.

Force and Stress Analysis

In the case of the cam shown in Fig. 6, let it be required to transmit a force Cf to the follower.

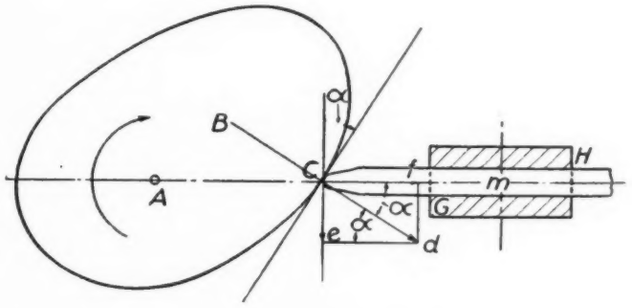


Fig. 6—Example in which travel of follower is constrained by guides

This force may be the net or useful follower load, or, in cases of relatively high speed cams, it may

include the acceleration allowance, found as indicated above. The follower travel is again constrained by guides to a straight line path, and again the line of travel passes through the center of rotation of the cam, *A*. The actual force of the cam against the follower acts along the line *Bd*, which is at right angles to the common tangent of the cam and the follower surfaces at their point of contact *C*. This force is *Cd*, and it must be of such magnitude that it has a component *Cf*, which is the known force, and another component *Ce* of unknown magnitude and acting along a line perpendicular to *Cf*, since *Ce* does not affect the magnitude of *Cf*. We have therefore a rectangular force parallelogram which is entirely defined because the direction of the diagonal and the length of one side are known.

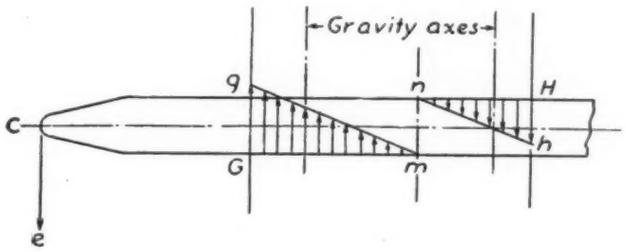


Fig. 7—Distribution of forces on follower

The cam torque necessary to produce the force *Cf* is $AC \times Ce$. But $Ce = Cf \tan \alpha$, so that the torque becomes $AC \times Cf \tan \alpha$.

We hardly need to refer to this formula to realize that the torque increases when the pressure angle α increases.

The force *Ce* produces a bending moment in the follower and bearing pressures of the follower against its guides, which pressures are maximum at *G* and at *H*. If the distance *CG* is at all considerable the bending moment should be investigated and the follower made heavy enough to provide a safe section modulus. The arm for the bending moment should be taken to *m*, the middle of the follower guides, and the bending moment becomes $M = Cm \times Cf \times \tan \alpha$.

In determining the bearing pressures on the guides it should be remembered that the forces are distributed as indicated in Fig. 7. Going toward the right from *G* the upward force is gradually reduced until we reach a point where this force vanishes altogether. Likewise, going to the left from *H*, the downward force is reduced and finally becomes zero. The tapering off of these forces is approximately inversely proportional to the departure from *G* and from *H*, so that the total vertical forces may be depicted by the triangles shown. Since there must be enough clearance between the follower and its guide to provide running fit, there must be a zone where there is neither a downward nor an upward force of guide against follower, but with the small clearances that may reasonably be expected with modern machining methods, this zone of zero force becomes negligible.

The total upward force of the guide is represented by the area of the triangle *Ggm*, which equals $\frac{1}{2} Gg \times Gm$. The downward force at the right is $\frac{1}{2} Hh \times Hn$. For the purposes of taking moments, both of these forces may be regarded as concentrated at the center of gravity of the respective triangle, or at points 1/3 *Gm* to the right of *G*, and 1/3 *Hn* to the left of *H*. Since the algebraic sum of all the vertical forces must be zero, $C + \frac{1}{2} Hh \times Hn = \frac{1}{2} Gg \times Gn$.

In Fig. 6, the force *Cd*, which is the direct load of the follower on the cam, gives a criterion of the width of the cam required, and indeed of the feasibility of using a point follower under the conditions of the problem. Since a point follower means rubbing friction with only line contact, lubrication under heavy loads becomes somewhat of a problem. The contact of the follower with any one line of the working surface of the cam is only momentary, and breakdown of the oil film does not necessarily mean injury to the cam. Since the cam usually is far more expensive than the follower this is fortunate, but the satisfactory working of the cam depends on the condition of the follower nearly as much as on the correctness of the outline of the cam, and the follower will wear down quickly if the lubrication is faulty. If the follower is hardened its life will be lengthened but abrasion or cutting of the cam surface is likely to result. There are no reliable data on the maximum loads that can safely be transmitted by point follower cams, and the matter must be left to the judgment of the

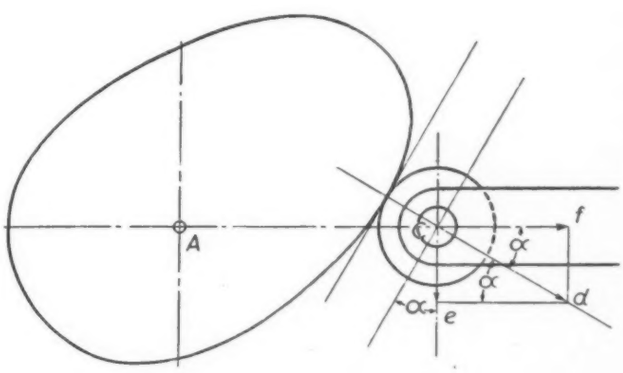


Fig. 8—Stress diagram of roller follower cam

designer. It is well to remember, however, that the quality of the lubricant, the manner of introducing it, and the reliability of lubrication are important factors.

Is a Stress Analysis Problem

The roller follower cam presents a problem, in so far as stress analysis is concerned, which is very similar to that of the point follower. In Fig. 8, the force of the cam acts along a line normal to the tangent common to the cam face and the roller, which line necessarily passes through the center of the roller. Moving the point of application of the force to C gives the direct cam load Cd, with its components Cf and Ce, as for the point follower. The cam torque required to produce force Cf becomes, as before, $AC \times Cf \tan \alpha$, but AC is now not the radiant of the cam but the distance from the center of rotation of the cam to the center of the follower roller. Here the force Cd becomes important as the determining factor for the size of the roller and the diameter of the roller pin.

The load capacity of the roller is a function of the diameter and the length, and is given by

$$DL = \frac{1.5W}{S}\sqrt{\frac{E}{25}}$$

where D and L are the roller diameter and length, respectively, in inches; W is the load in pounds; S, the allowable compressive stress of the roller material in pounds per square inch; and E is the modulus of elasticity.

The pin should be designed on the basis of shear strength and bearing area, the data for the latter being available in all mechanical engineering handbooks.

The acceleration of the follower working with a barrel or cylindrical cam cannot be found readily from the cam itself, but may be obtained from the displacement chart. To give correct results the base line of the chart should be made equal to the length of the pitch circumference of the cam, that is, π times the mean of the outside diameter and the diameter to the bottom of the groove. This would necessitate the construction of a special curve, which labor ordinarily is not warranted by the degree of accuracy required. A very good approximation can be obtained by using the ordinary displacement chart constructed as a part of the usual layout work for the cam groove. Fig. 9 shows a part of such a graph. The complete curve is the expansion of the path of the center of the follower roller for one turn of the cam, and each ordinate represents the follower travel from some position of reference, which is given by the base line of the curve. The base line is divided into equal spaces corresponding to equal angular displacements of the cam. But each angular displacement represents the passage of a definite length of time as well as of a definite space, but to a different scale.

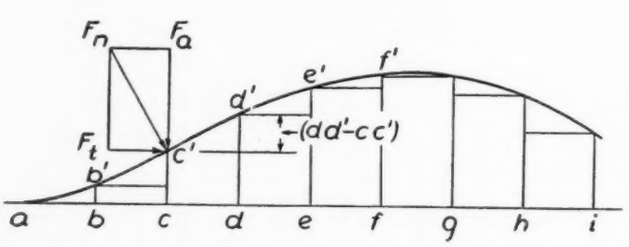


Fig. 9—Using barrel cam displacement chart for approximating acceleration and cam forces

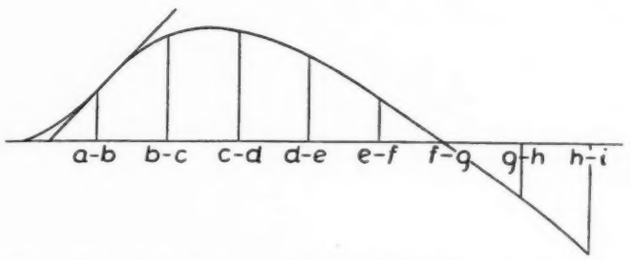


Fig. 10—Velocity diagram obtained from cam chart shown in Fig. 9

When the cam is in such a position that the center of the roller is at c', it has moved a distance cc' from the reference position. After the passage of the time interval represented by cd, the follower is at d', a distance dd' from the base line. During time cd the follower has therefore moved through distance $dd'—cc'$, and since velocity equals displacement divided by time we may write,

$$v = \frac{dd'—cc'}{cd}$$

where v represents the velocity for the time interval cd. It is convenient to select the scale so that cd represents one unit of time (but not necessarily one second or one minute), in which case the expression becomes $v=dd'—cc'$. The subtraction is best done graphically, as indicated in the figure.

Obtaining Velocity by Graphical Method

Plotting the velocities obtained from Fig. 9 gives the data for a velocity graph, Fig. 10. Each velocity found is the average for its time interval, so that the ordinate representing any velocity should be erected at the mid-point of its time interval. Thus, for example, the ordinate marked c-d in Fig. 10 is located midway between positions c and d of Fig. 9, the height of the ordinate giving the velocity to any convenient

scale. When the velocity curve has been drawn in, the acceleration may be found by the tangent method as explained for disk cams in conjunction with Fig. 4. If the ordinates in Fig. 9, and hence also the ordinates in Fig. 10, are placed infinitely close together so that the distance between them approaches zero as a limit, we get absolute accuracy, except for the errors always present in graphical construction. Since it is impossible to deal with an infinite number of ordinates by graphical means, absolute accuracy would necessitate integration by means of calculus, which in turn would necessitate writing the equation of the displacement graph—a task which seldom is easy and which often is impossible of exact solution. By placing the ordinates reasonably close together and exercising care in the execution of the work, the accuracy obtainable by the method here outlined will be quite sufficient for all practical purposes.

Both the velocity and the acceleration of the follower have here been regarded as rectilinear quantities while the follower roller necessarily travels along the arc of a circle if a rocker follower is used, so that in reality angular velocity and angular acceleration result. But the ultimate follower rarely is the rocker itself, but some machine part which is actuated by the rocker and which travels along a straight line path. The velocity and the acceleration of the ultimate follower are therefore rectilinear quantities, which justifies the above method.

Special Curve More Accurate

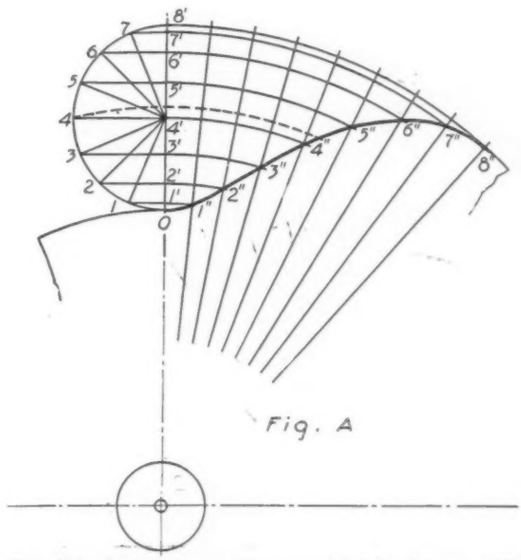
The cam forces may be found from the displacement chart direct, although here again greater accuracy is obtainable if a special curve is constructed and the base line is made equal to the circumference of the pitch cylinder of the cam. In Fig. 9, let $F_a c'$ be the resistance of the follower to be overcome by the cam. In high speed cams this force should include allowance for acceleration, as was explained for disk cams. The actual force is $F_n c'$, drawn normal to the displacement curve. $F_n c'$ may be divided into components $F_a c'$, which is usefully expended, and $F_t c'$, which is the tangential load and which, when multiplied by the pitch radius of the cam cylinder, gives the torque. $F_n c'$ governs the size of the follower roller and pin, as was the case with the corresponding force for disk cams.

Suggests Plan for Modification of Method for Obtaining Harmonic Curve

THE following is a letter received from one of our readers commenting on the article giving suggestions for laying out cams, which appeared in an earlier issue. The criticism and suggestion contained are extremely welcome. They are constructive and throw further light on this important subject.

IN MR. JACOBS' article, "Practical Suggestions for Laying Out Cams," which appeared in the October issue of MACHINE DESIGN, there is given in conjunction with Fig. 9, page 39, a method for laying out the cam surface for simple harmonic motion of the follower. This method is approximate and gives a follower movement which is not quite as desirable for high speed cams as is true simple harmonic motion. It is possible to obtain true simple harmonic motion by a slight modification of Mr. Jacobs' method, as described below.

In Fig. A, which is an enlargement of the upper part of Fig. 9 in the article under discussion, the construction semicircle is divided into eight parts, as before. This gives division points 1, 2, 3, etc. on the arc. From these points lines 1-1′, 2-2′, 3-3′, etc., are drawn at right angles to the cam radiant passing through the center of the construction circle. From points 1′, 2′, 3′, etc. arcs are struck to the corresponding cam divisions, giving points 1″, 2″, 3″, etc., through which



In this layout, arcs are struck from points 1′, 2′, etc. to the corresponding cam divisions, giving 1″, 2″, etc. as points through which the cam curve is drawn

the cam curve is drawn. It will be seen that if the arcs are struck from the circumference of the construction circle (as from point 4), rather than from the diameter of that circle (as from point 4′), the resulting cam curve will depart materially from that shown in Fig. *A*.

Better Suited for High-Speed Cams

Mr. Jacobs points out that gravity of constant acceleration and constant retardation motion is more ideally suited for high speed cams than is simple harmonic motion, and he gives a method for constructing gravity cams, in Fig. 8 of his article. It is possible, however, to dispense with the drawing of the ellipse, which is apt to be a troublesome bit of construction. In Fig. *B*, let 0-6′ be the follower travel. Draw the oblique line *Om*, laying off along it distances 0-1, 1-2, 2-3, etc., in the ratio 1: 3: 5: 5: 3: 1 to any convenient scale (or in ratio 1: 3: 5: 7: 7: 5: 3: 1, or any similar series of odd figures, noting that the largest figure must appear twice). While the follower travels from 0 to 6′ the angular movement of the cam is from 6′ to 6″, which must be divided into the same number of equal parts as there are parts along the line 0-6. The points 6-6′ are now connected, lines 5-5′, 4-4′, etc., are drawn parallel to 6-6′, and arcs are struck from points 1′, 2′, etc., to the corresponding cam radii, obtaining points 1″, 2″, 3″, through which the cam outline is drawn.

The reason for dividing the follower travel into ratio 1: 2: 3:—3: 2: 1 is that uniform acceleration is expressed by the gravity formula $h = \frac{1}{2} g t^2$, h being the height of free fall, g the gravity constant, and t the time. This gives movements of 1^2, 2^2, 3^2 for 1, 2, 3, units of time, or movements of 1, 3, 5, etc. for each successive unit of time. For retardation the acceleration ratio is simply reversed.

It may be noted that the simple harmonic and gravity outlines are quite similar in general appearance, and indeed the simple harmonic serves as well as the gravity cam except for very high speed work.

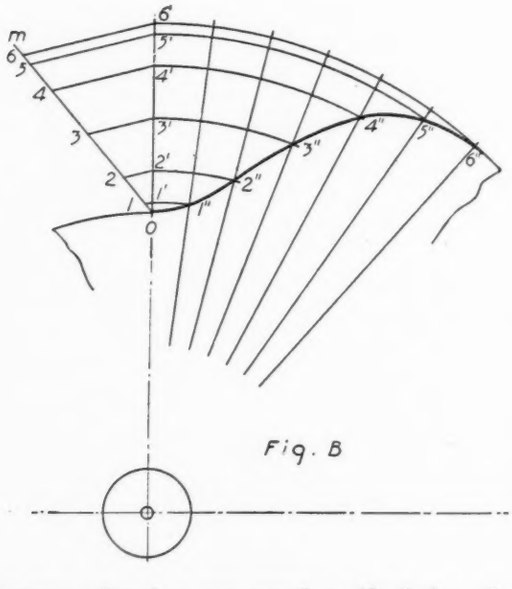


Diagram showing proposed method for obtaining gravity cam curve

Two New Members Added to the Engineering Family

TWO new members have been added to the engineering family in recent years—the research engineer and the development engineer.

A research engineer searches for new information on elements and relations of nature. His function is to discover. A development engineer is a continuation of and complement to the research engineer, for he uses research data to create new things which industry needs. His function is to invent.

Lacked Distinction in Past

In the past it has not been understood generally that the functions of research and development engineers are fundamentally different. Many large manufacturing concerns have employed hundreds in research departments without distinction between research and development engineers. Other companies have had development departments or experimental laboratories where research and development have been carried on with little apparent comprehension of the fundamentals and details of this work. Such conditions were normal, and accounted for by the newness of these industrial activities.

More recently industry has begun to adjust itself to the new condition. There are two noticeable factors in this adjustment. First; a tendency to divide the research department into two parts, one specializing in research as such, the other in finding the best applications of the research data. Second; gradual merging of the designing or engineering department into the development department.

Design is a final form of the results of research and development and in itself is an inventive function. Every designer knows how many difficulties he has to overcome during the process of designing.

In the selection of development department personnel the ability of a man counts more than his store of knowledge. From this point of view, colleges do not help industry much. They produce individuals with specific stores of tech-

nical knowledge while industry needs men with specific ability. Research engineers possibly can be produced by the present technical colleges without much special effort. But the situation with the development engineer is different because he is an industrial inventor. This new member of the engineering family presents an interesting problem which can be solved eventually through joint efforts of industry and colleges.

Development engineering has become a distinct engineering art with its own peculiar laws and methods. However, the development department can be organized and managed in a scientific way, and persons with an inventive turn of mind trained to exercise their ability with a remarkable degree of efficiency.

The fact is well recognized that the number of inventions not only has been increasing during the past hundred years but that the speed of increase also has been increasing. The appearance of research and development engineers as members of the engineering family indicates the tendency on the part of industry to utilize these forces in a systematic way. This phenomenon well may prove to be the beginning of a new industrial era—the era of organized exploitation of inventive energy.

L. A. TROFIMOV, M. S.

Lest We Forget

Complex Machine Age Is Indebted To Simple Fundamental Principles

THE fundamental importance of design is emphasized in a recent advertisement published by the Cadillac Motor Car Co. in the *National Geographic Magazine*. This announcement also reminds designers of essential simplicity of all machines which makes it desirable always to bear in mind the simple fundamental principles of applied mechanics to which our entirely complex machine age civilization is indebted. The care and thought which designers of fine automobiles devote to the correct application of fundamental principles is emphasized.

Archimedes 287-212 B.C. | Leonardo da Vinci 1452-1519 | Galileo 1564-1642 | Stevinus 1548-1620

Sires of the Machine Age

"We are inclined to think of motor cars, radios, phonographs and motion pictures as modern inventions", it is stated. "And they are to a large degree. But they could not have been invented had not many fundamental laws in mechanics, engineering and electricity been established long before these devices were thought of.

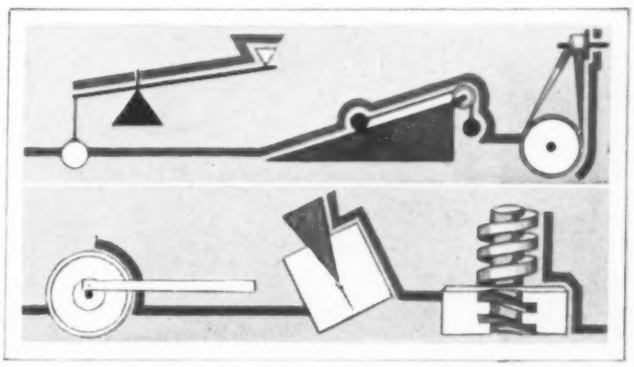
"Motor cars are tremendously indebted to the past. Consider, for example, just the transmission.

"Many people, not mechanically inclined, would probably say it was like a box of gears. So it is and gears remind us of something we had almost forgotten. It is generally taught when we study elementary physics. It is this:

"Every machine can be reduced to a few simple elements, called the six mechanical powers. The primary ones are the lever, inclined plane, and pulley. The others, derived from these, are the wheel and axle (derived from the lever) the wedge, and the screw (both derived from the inclined plane).

"We are indebted to Archimedes, Galileo, Leonardo da Vinci, Stevinus, Newton, and other celebrated mathematicians and scientists of the past for formulating the principles of the six mechanical powers and developing their application so that we can use them today in our numerous machines in ways the ancients never dreamed of.

"Gears in their operation hark back to the lever principle. And it is common knowledge that gears are one of the oldest methods of power transmission for short distances. Transmissions have been doing this sort of a job ever since the first car reached the street."



The Six Mechanical Powers Simply Illustrated

Left to right: Lever, Inclined Plane, Pulley, Wheel and Axle, Wedge, Screw

How Field Facts Help Sales and Design

By Chapin Hoskins

ON THIS and the accompanying pages is presented the concluding portion of an article which commenced in the November issue of MACHINE DESIGN. *In that issue the author related the experiences of certain factory executives who, for various reasons, had come to the conclusion that their plants were being used as a "testing ground" by machinery manufacturers. However, he explained that although this procedure might be overdone in certain cases, in others any facts gathered from the observance of actual field performance were put to good use in assisting design improvement. The accompanying article cites numerous instances of how such facts are gathered and put to the best advantage by leading manufacturing companies.*

TO THOSE readers whose business is the designing of machinery or apparatus produced in quantity, and who cannot possibly have an erector representing the company on each job, it may seem that the Dexter method applies only to machinery that is more or less individual in design. But no matter what quantities may be, the principle of seizing every opportunity to obtain and to profit by direct knowledge of the performance of a product in the user's hands can be applied.

Here, for instance, is the procedure followed by the Brown Instrument Co., makers of indicating, recording and controlling instruments for industrial use.

"Our Engineering Department ordinarily receives its information as to what is required from three general sources.

1. Such service reports as appear to be of value. This means, of course, the reports from our staff of employes who travel about the country out of our different offices assisting our customers in the proper maintenance and operation of their instruments of our make.
2. Suggestions and complaints from sales representatives are usually answered by the engineering department. This, of course, refers only to such suggestions and complaints as involve difficulties relating to the operation of instruments of our make in the service of the customer issuing the complaint. The

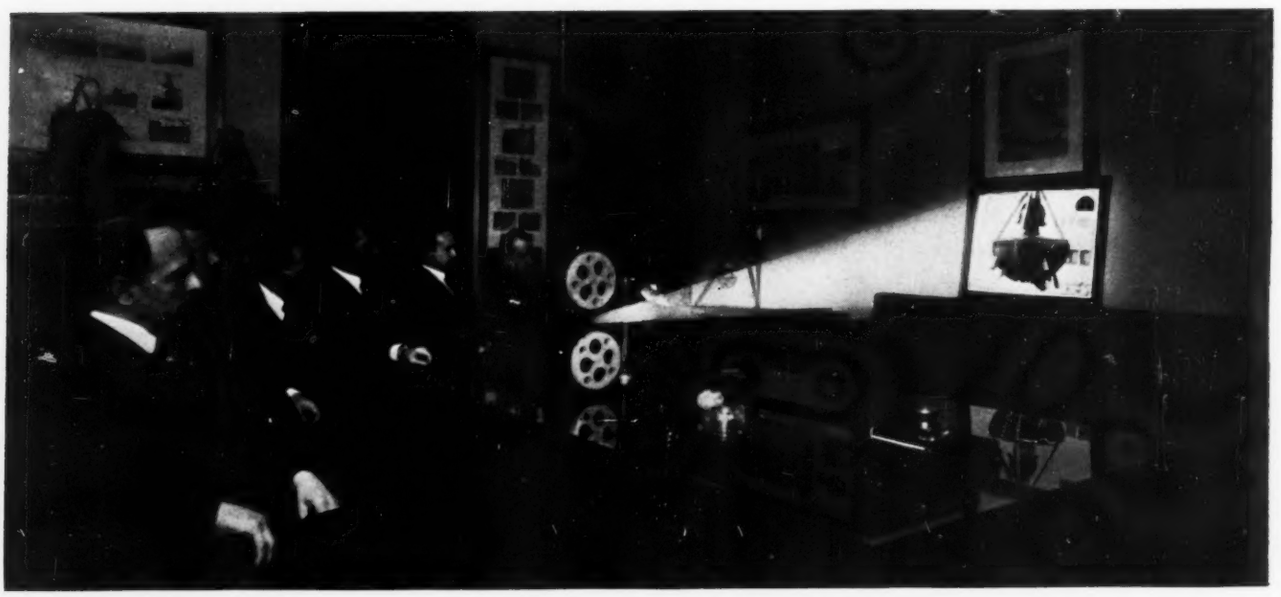


Fig. 1—Sales and design executives studying motion picture of field performance of their product

engineering department naturally does not handle complaints regarding deliveries, etc., that have no connection with engineering. In handling the complaints that come to their department, the members of the engineering department naturally accumulate data and ideas leading to the improvement of our instruments.

3. Actual contact with the customer.

"It should be stated, however, that we maintain what is, in proportion to the size of our organization, a rather large research department. In this department new instruments are developed and radical improvements of instruments already in our line are evolved and perfected. This department is made up of scientists and engineers who by natural equipment, training and experience are qualified to study the needs of the industrial arts with respect to instrument requirements such as we might profitably fill; and to create new instruments for these needs to be added to our line. The instruments thus created are thoroughly worked out before being put into the field, so thoroughly that comparatively few 'bugs' are found after the product is put into service.

"In addition to our research department we have an engineering development department, which studies the instruments in the field, paying particular attention to requirements for adapting the instruments to meet the various applications and conditions encountered.

"Moreover, all of our salesmen are engineers. They are not merely salesmen, but are able to study the operations conducted in the plants of our customers and prospects, and to work out practical applications of our instruments to meet the service requirements of these operations affording opportunity for the profitable use of instruments.

"This function of our sales engineers amounts to an extension of the resources of our company centered in our research department."

In this set-up, perhaps the most interesting detail is the engineering development department. Here you have the very essence of legitimate use of the customer's establishment as a laboratory. Where the research deparment iself might incline toward theoretical perfection, this special department for studying customer conditions could undoubtedly be relied upon to be severely practical.

Adaptations of these two performance study set-ups (of Dexter Folder Co. and The Brown Instrument Co.) can be counted on to meet a wide variety of conditions in machine design. Any well worked out organization of the same character would introduce the constructive viewpoint that is lacking when complaints are the chief source of designer-customer contact.

Study of Possibilities Suggested

Any machine manufacturing organization which is contemplating improvements of this nature will want, however, to study the possibilities in greater detail, and to devise a set-up which exactly meets its own conditions.

In this task the following analysis and further examples from the practice of successful companies should be of value. There are, to begin with, three things you want to know about the product you have designed after it has reached the customer:

1. Is its mechanical action perfect?
2. What results does the machine give?
3. What is the customer's reaction?

1. Mechanical action (or electrical, as the case may be) is the detail which the majority of engineering departments study most faithfully. It is the problem most likely to have been satisfactorily solved before the machine leaves the maker's establishment. Under the severe conditions or actual use, however, mechanical or structural weaknesses may develop, or opportunities for mechanical improvement become apparent.

2. Results and mechanical performance are of course far from being the same, although all too frequently confused in investigations of

DAILY SERVICE REPORT

Name of Bakery_____

City_____ State_____ Date_____

Serial No._____ Machine—Run from_____ M to_____ M

Brand of Bread	Quantity Wrapped	Cripples	REWRAPS: Open Ends	Open Bottom	Torn Paper	Other Causes	Total Rewraps

Note: Give reasons for Cripples, rewraps or other troubles.

Remarks and details: _____

Signed:_____
Service Dept.

Fig. 2—Type of daily service report used for recording performance of machines in customer's plants

"trouble." A production machine supposed to deliver 1000 units of product per hour may turn out only 800 under use-conditions—and yet be mechanically perfect. It is a failure to descern this difference which causes an occasional short-sighted engineering department to be unshakeable in its conviction that a machine is properly designed when, as a matter of fact, it is not "delivering the goods."

3. As for the customer's reaction, this is the most difficult of the three points to gain an understanding of, yet in many respects the most important. "The customer is not using the machine properly" is perhaps the most frequent explanation of machine failure. The fact is, of course, that in any given field a certain percentage of customers never will use the machine properly, and it is up to the design department to take note of this in all its designs and redesigns. (If

the dashboard of an automobile were as complicated as the interior of a railroad locomotive cab, how many automobiles would be driven? The designer of a locomotive can assume that its operator will be a trained engineer. But the motor car designer must assume that the driver knows nothing of mechanics when he first climbs into the driver's seat, and perhaps not much more after several years' driving experience.)

With these three details in mind (mechanical action; results; customer's reaction), the experience of a great many companies may be drawn on in setting up an appropriate system of performance study. Here are a number of suggestions.

Mechanical Action

(1) Such questions as whether all the parts of a machine work together in the way they were intended, whether the design and choice of materials minimize breakage through strain and breakdown through wear, etc., are "old stuff" to any practical engineer. One idea that will, however, be new to many has for several years been used by the Hayward Co., makers of excavating buckets. This company takes motion pictures of its equipment in action on the customer's job. These pictures are then studied by the chief engineer and his assistants, who can observe any set of movements over and over again, at their leisure, in their own office. They find this method valuable not only in discovering opportunities for refinement of design, but also in assuring themselves that mechanical operation is what it should be when customer or salesman incorrectly believes it otherwise.

(2) When a machine is of sufficient size or complexity to justify being set up by a representative of the maker, the erector's report gives the first opportunity for a test of results. Where the machine is sold with definite performance guarantees, a formal test is usually necessary. The method of Dexter Folder Co. has already been described. Where measured quantity performance must be tested, a workable procedure is that of Carrier Engineering Corp. (air conditioning, drying and refrigerating apparatus), as reported by Herman Worsham of that company:

> "Practically every Carrier System, upon its completion, is visited by a control superintendent or supervising engineer. His job is to remain with the system for several days observing the operation and giving the owners instructions concerning the equipment. It is from his report as well as reports from the sales engineer responsible for the contract that we check the accuracy of our estimates. If discrepancies are found the facts are placed before the head of our estimating department. Briefly this is how we do it and still we have no standardized system of reports which we follow.

(3) When machines do not and cannot have individual setup, there are usually "rejects" in sufficient quantity to permit systematic analysis. Radio tubes, for instance. Where millions are manufactured, a return that is only a fraction of one per cent gives considerable opportunity for study. De Forest Radio Co. has learned, for instance, in studying rejects, that many "unsatisfactory" tubes are in fact in excellent condition and that the great majority of failures is due to improper handling by customers. When inherent defects in tubes are discovered, however, the company's engineers take steps to strengthen the tests given to finished product before shipment.* In some cases, design changes might result.

(4) Next to erection reports, systematic service or maintenance calls offer the most positive, complaint-free opportunity for performance study. Thus an eastern manufacturer of bread wrapping machinery daily receives from his field service men reports which disclose the percentage of loaves which become "cripples" or "rewraps" and which include an analysis of causes of rewraps.

(5) The motion picture method already mentioned is also used as a study of results. Thus the question whether a given orange-peel bucket takes a full load at each dip can sometimes be answered more easily from motion-picture observation than in any other way.

Customer Reaction

(6) The study of what-the-machine-means-to-the-customer may get under way at the time of installation, as in the Dexter Folder and Carrier Engineering organizations. It is entirely possible for the man in charge of installation to regard the customer as a queer sort of animal who wants to do funny things with a perfect

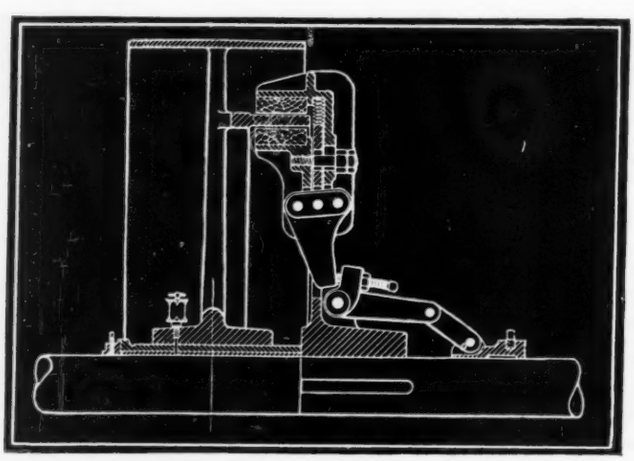


Fig. 3—Early model of Hill transmission clutch

**Radio Manufacturers' Monthly*, July 1929.

piece of machinery. (Ask your own production head how often he meets with this type of mind!) But if he knows that the engineering department back home really wants facts, the average installer can be a gold mine of information.

(7) Service reports, complaints and every other type of more or less routine contact with the user also offer information of value to the designer—if not treated as routine. At Hardinge Co. (mining machinery), for instance, operating data and trouble reports must go through the hands of the chief engineer, sales manager, and works manager, says John J. Cadot, vice president. In addition, the chief engineer himself visits a job when a service report indicates that he is needed.

(8) A study of rejects, such as that made by De Forest Radio Co., may be more than anything else a study of the customer phase of the design problem. Most of their trouble, the De Forest people say, is caused by you and me, as radio users, putting tubes into wrong sockets or inserting tubes with our current turned on. Here is clear indication of the need for radio tubes that proof. Every machine has the same need in some degree.

Sales Conventions Are Valuable

(9) A sales convention holds important contact possibilities, the Edwin L. Wiegand Co. (electric heating units) has found. This company has a peculiar design problem, in that the design of its own product, which only in the broadest sense of the word may be considered a machine, has been standardized over a period of years, and the real difficulty is to get other manufacturers who make use of heating units to adjust their own designs to the standard. The value of the sales convention in this case is chiefly in delivering the engineering point of view to the salesmen, but other companies have found that in a convention of this kind practical information can be made to flow in the other direction too.

(10) Actual personal contacts between designer and customer are always of value. Thus engineers of the De Vilbiss Co. (spray painting equipment) are on occasion sent out to call upon the trade with the company's sales and service men, "to get first hand information that will assist them in improving the designing and construction of equipment to meet the customer's requirements," R. A. Guyer, of the company, tells us.

(11) A more intense development of the engineering customer contact leads to such an engineering development department as that of the Brown Instrument Co., already described. Less formally, there may be use of sales engineers, as at the Dexter Folder Co. and the Edwin L. Wiegand Co.

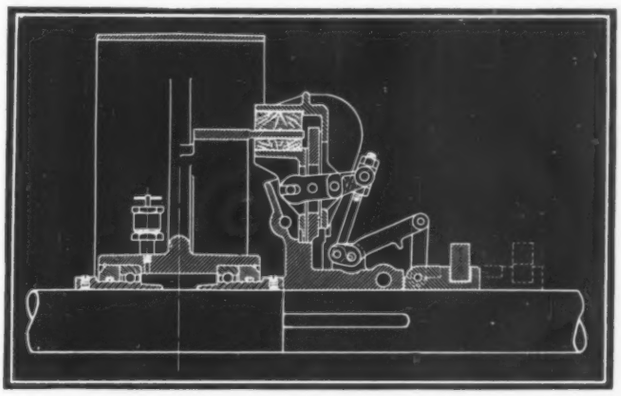


Fig. 4—Recent design of Hill clutch incorporating refinements to meet field conditions

There are, of course, not twelve but many times twelve ways in which those responsible for the design of a product may learn what happens to their product in actual use, with a view to design improvement. Those which have been described in this article will, however, cover a broad range of design problems.

In the light of them, how does your own company's design improvement system "stack up?" How far have you gone since the days of the 1904 automobile?

It may pay you to check up.

"Welding Scattered Information"

Gentlemen:

Unsolicited I wish to tell you how much I appreciate the wholesome character of MACHINE DESIGN. The second issue (October) is at hand and seems to be even better than the first.

It impresses me as being a sort of journalistic flux; welding scattered information into coherent knowledge.

More power to your ingenuity in fostering and pioneering this distinctly new undertaking in which you have visualized a great service, and I sincerely hope you realize serene satisfaction of purpose.

We, as you know, have subscribed for two years in tribute.

JAS. L. HEROLD, Designing Engineer,
Barry Wehmiller Machinery Co., St. Louis.

A copper-lead bearing composed of 25 per cent lead and 75 per cent copper has been developed for heavy-duty automobile engine practice. It is cast and requires no lining or backing.

German Engineers Solve Problems of Compressor Design

DESIGN of compressors employed in the production of ammonia involves many special problems, particularly in regard to gas tightness. German engineers who have had an unusually rich experience in the development of chemical equipment, have worked out a number of interesting solutions for problems in ammonia gas apparatus, which should prove worthy of the attention of American designers. The accompanying article is abstracted and translated from the German publication, V. D. I. for Oct. 26, 1929.

TO PRODUCE ammonia synthetically, there is required in the first place a compressor which draws in the coke oven gas at normal pressure and compresses it to 11 to 12 atmospheres. It therefore must operate in two stages. If the compound or usual tandem arrangement is decided upon, with one cylinder for the first stage and a second cylinder for the second pressure stage, then both the cylinders must be equipped with two sets of stuffing-boxes because, owing to the large size of the pistons, they must be provided with front and rear guides. By combining both of the pressure stages in one cylinder, the four stuffing-boxes may be eliminated.

Is Not Solution to Problem

The known differential arrangement with plunger pistons does not solve this problem. A double acting first pressure stage with a single acting second stage, results in an unsatisfactory distribution of the piston pressures in the in and out strokes. The Frankfurter Maschinenbau A-G., in order to eliminate this undesirable feature, has developed a close-coupled tandem compressor, in which both pressure stages are single acting, with an equalizing chamber between them.

Fig. 1 shows a view in section of such a two-stage coke oven gas compressor, having an hourly capacity of 8000 cubic meters. Space *b* is the equalizing chamber connected with the intake ducts. In order to obtain equal pressures on the low pressure side, the second stage piston is provided with holes. The cross-head attaches to rod *e* and the tail-rod is indicated at *f*. When the piston is moving in the direction from *f* to *e*, the piston pressure, leaving out of consideration the resistance due to friction, amounts to 47,000 kilograms and when moving in the opposite direction it amounts to 34,500 kilograms.

On the other hand, a compressor having the same capacity, operating at the same speed and the same length of stroke, if working double acting on the first stage and single acting on the second, would have a piston pressure of 62,000 kilograms on the forward stroke and 19,000 kilograms on the return stroke. The close coupled compressor hence shows a saving of 25 per cent in the maximum piston pressure and a more uniform distribution of the piston pressures on the forward and return strokes. The cylinder consists of two parts, the one containing the first pressure stage and the equalizing chamber, the second part containing the second pressure stage. The placing of the two parts inside each other results in a short cylinder construction, which makes possible a thorough cooling of the second stage. The gas flow in the first stage is controlled by the Koster valve gear, while in the second stage it is controlled by a free-working disk valve.

In these compressors, the control over a wide limit of the suction capacity is very important, in order to be able thereby to meet the varying operating requirements. As the compressors are frequently motor driven, it must be possible to vary the suction capacity without changing the speed of the electric motor, and without at the same time resulting in any waste of energy. This requirement is met by an arrangement of two special control devices.

Load Valve Is a Controller

One control device is the load valve located midway in the stroke of the compressor cylinder, Fig. 2. If this valve is closed, then the compressor draws in its full volume of gas. If the valve is opened completely, then the drawn-in gas will be forced back into the intake piping during one-half of the compression stroke, and the balance will not be compressed until the piston has passed beyond the opening in the cylinder. With the valve completely open the capacity of the

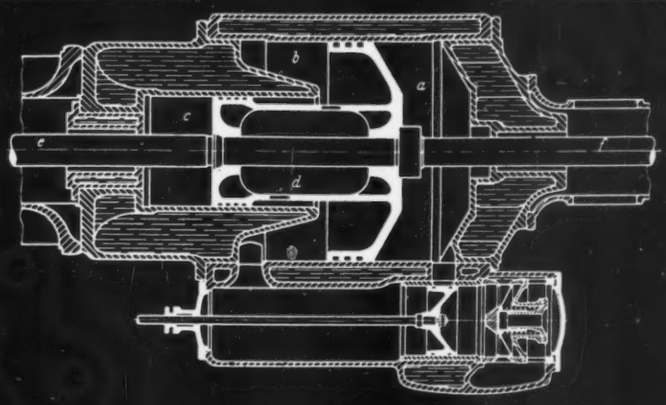


Fig. 1—Cylinder of two-stage coke oven gas compressor

a, first stage
b, equalizing chamber
c, second stage
d, openings in second stage piston
e, cross-head end
f, tail-rod guide

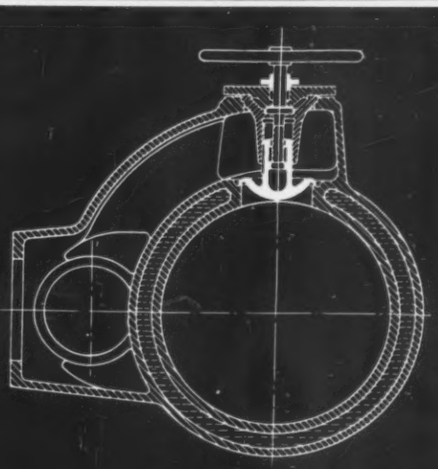


Fig. 2—Loading valve in center of compressor cylinder.

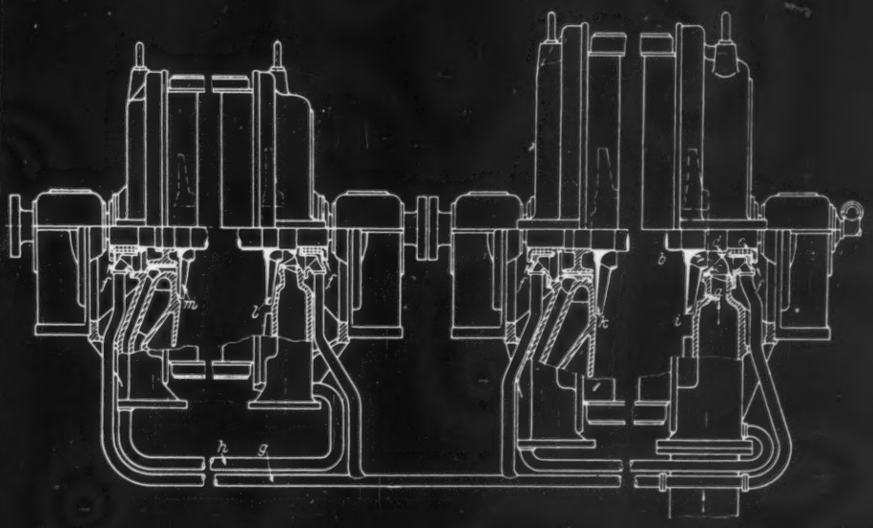


Fig. 3—Turbo-compressor for coke oven gas

a, gas inlet into compressor
b, gas inlet into first runner
c, and d, labyrinth packing
e, carbon packing ring
f, gas outlet into air
g, pressure equalizing ducts.
h, intercommunicating piping
i, runners 1 to 4, blade width 50 millimeters
k, runners 5 to 10, blade width 30 millimeters
l, runners 1 to 6, blade width 16 millimeters
m, runners 7 to 13, blade width 12 millimeters

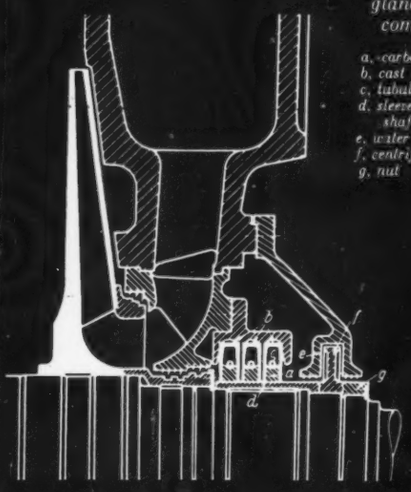


Fig. 4—Gas tight glands for turbo-compressors

a, carbon packing ring
b, cast iron chambers
c, tubular spring
d, sleeve on compressor shaft
e, water seal gland
f, centrifugal slinger
g, nut

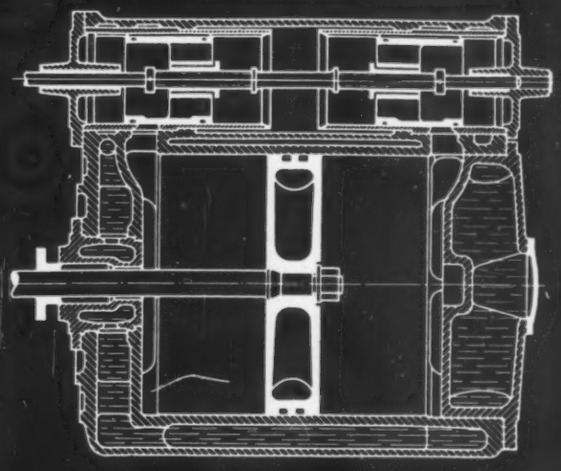
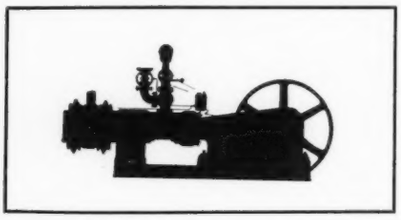


Fig. 5—Piston valve control

compressor will therefore be reduced one-half. By adjusting the valve, suction capacity may be varied at will from full to half load.

The second device, which makes it possible to vary the capacity of the compressor from full load to no load, is the auxiliary valve control shown in Fig. 5. In single acting compressors it consists of a sliding piston valve, in double acting compressors it consists of two sliding pistons adjustably mounted on a spindle provided with square right and left threads. A handwheel serves to vary the adjustment. With slide valves in the position shown, the openings in the cylinder are closed and the compressor has full suction capacity. If the two sliding valves are pushed towards each other, and the openings are completely uncovered, then all the gas drawn in will be forced back into the ducts through the valve chest. In intermediate positions of the valves, the gas flow is throttled, and the capacity of the compressor thus may be controlled from full load to no load. The controlling devices may be arranged to perform the regulation automatically, by means of servo-motors or an oil pressure pump.



For capacities of more than 24,000 cubic meters per hour, when compressing coke oven gas, turbo-compressors are employed. Here also gas-tightness is important, for which reason special care is given to the design of the packing boxes. Fig. 3 shows a turbo-compressor for coke oven gas which at a speed of 3600 revolutions per minute compresses 36,000 cubic meters of gas per hour to 10 atmospheres absolute. The compressor has two housings. In the first the gas is compressed in ten stages to 3.5 atmospheres absolute, and in the second housing the gas is compressed in 13 stages from 3.5 to 10 atmospheres absolute. The gas enters the compressor at *a* and enters the first runner at *b*.

Runner and shaft are provided with labyrinth packing *c* and *d*. Ahead of the labyrinth packing is interposed the carbon ring packing *e*, which makes the shaft leak-proof to the outside. Any gases still escaping are conducted out into the open air through the suction pipe at *f*. The three other packing boxes are constructed in a similar manner although labyrinth packings also are mounted between the thrust disk and the housing. A duct *g* has branches which connect with the chambers ahead of the carbon ring packings and equalize the pressures; similar ducts *h* perform the same function on the suction and pressure sides of the labyrinth packing.

Fig. 4 shows another arrangement for leak-proof packing boxes. The carbon rings *a* consisting of two or more parts are mounted in cast iron U-shaped chambers *b* and are pressed against a sleeve on the compressor shaft by means of a tubular spring *c*. As a result of the gas pressure existing in the chambers, the carbon rings are self-tightening. Ahead of the carbon ring packing is a water seal gland *e*. In this there is mounted a runner *f*, which fits on the compressor shaft between the bushing *d* and nut *g*. On both sides of the runner ring *f* is the packing gland *e* made tight against the bushing *d* and the nut *g* by means of the labyrinth packings.

The water seal gland is provided with attachments for connecting the water supply and drain-off pipes. As soon as the compressor starts rotating, water is supplied to the gland, which due to centrifugal force is pressed against the walls of the gland by means of the ring slinger. The water supply is so regulated that water always remains around the gland, into which the ring dips. In this way a dependable water seal always is maintained. Turbo and piston compressors also may be so coupled together, and the gas pre-compressed in the turbo-compressor and brought up to its final pressure in one stage by means of the piston compressor.

Roller Chain Data Book Is Published

Link-Belt Co., Indianapolis, has just published a new roller chain data book, No. 1257, which is believed to be the most complete manual yet developed for properly selecting and applying chain.

This 96-page book illustrates the construction of the chains and wheels, and presents many pages showing practical applications of Link-Belt roller chain on light and heavy duty industrial drives, and on all types of machinery, tractors, trucks, farm implements, etc.

All data are clearly compiled to enable one to select the proper chain and wheels to suit individual conditions, and to figure costs. Also an additional feature of value is a presentation of lists of wheels up to 81 teeth. All pitches of chains are carried in stock.

This book is worthy of a place in every engineer's and mechanical man's library. A copy will be sent gratis, if requested upon business letterhead.

According to a report of the National Safety council one in every 14 industrial workers has a lost-time accident during the year, with an annual loss of 72 days for each injured worker.

Organization and Supervision of Design Department

By John F. Hardecker

Part IV

Rules and Regulations—Changes to Drawings—Meetings for Discussion—Value of Specialists' Advice—Need for Design Library

RULES and regulations are deserving of the best executive attention in a design department. Indiscriminate issuing of rules in a haphazard manner is to be avoided, for by no other means can an efficient design organization be more quickly wrecked on the rocks of dissension and inefficiency. To properly qualify as a good designer, a man must be possessed of imagination, initiative and an ability to seek essential truths in a maze of details. Therefore he must never be expected to regard routine as something requiring his eternal vigilance. In other words, rules and regulations are to be established solely as an aid to the designer in the accomplishment of his essentially more significant duties, and always must be a path and never a destination in the quest for good design.

The fact that an individual may at some time do a thing incorrectly, is not necessarily sufficient justification for issuing a rule against it. In most cases, it is better to quietly correct that individual personally, than to promulgate a regulation about it. Rules should be essentially expressions of basic principles and procedures. Special cases should be handled as such, and should not occasion rules having no general application.

The Fewer Rules the Better

Useless rules not only confuse the really significant ones, but to a thinking individual they also indicate a desire to shirk executive responsibility by merely hiding behind the fact that a regulation has been issued about everything, and therefore a perfect alibi exists for the executive to offer as an excuse when an error arises. If a rule or regulation is worthy of official promulgation at any time, it is likewise worthy of being preserved in a proper way. Therefore it is best to plan from the beginning to issue all rules in a uniform way, preferably in the form of an engineering department

MANY readers have found the information contained in Mr. Hardecker's previous articles to be invaluable to them in the management of their engineering departments. The present article contains further valuable and interesting information, and in the next the author will deal in a comprehensive manner with such important subjects as patents, systems for numbering machines, drawings and parts, and clerical work of the department.

manual which can be bound uniformly with the design standards. In this way, a logical check on the utility and advisability of any new rule immediately presents itself, for the rule that is not worthy of permanent preservation is better issued as verbal instruction to those immediately concerned. Made available in this way, the manual becomes a proper instruction book for all new design personnel, to be carefully read and studied before any actual work is undertaken to be executed.

Rules and regulations for a design department are so intimately linked up with the products with which the organization as a whole is concerned, that only the merest generalities can be logically attempted. In view of the service relationship of the design department with other departments of the concern, new rules should be subject at least to the comment of other department heads before official issue, unless they are obviously purely internal to the design department.

Drawing sheet sizes may not appear at first glance very important, yet they are worthy of serious consideration from the very beginning of design work. True, most organizations grow from small beginnings, and in their earlier history drawing sizes appear to be a small problem.

System Should Allow Expansion

Yet the very first drawing made should be in accordance with a system that will permit of infinite expansion. This system also should allow of proper preservation and accessibility of the drawing at any time, no matter how long the intervening time may be between when it was made and when it is desired for reference or information.

Regular plan filing cabinets are commercially available in three standard sizes, 24 inches x 36 inches, 30 inches x 42 inches and 36 inches x 48 inches. These dimensions represent the actual tracing sizes. The drawers can be divided into halves, quarters, sixths and eighths, by the insertion of suitable drawer dividers. A proper selection of subdivisions of the basic size sheet will determine the size of the smallest size sheet. Extra large drawings can be made of varying length, with the width conforming to one of the basic dimensions given, so that they can be rolled for filing. Thus by the selection of one basic size of plan filing cabinet and the governing of drawing sizes accordingly, the maximum flexibility of plan filing may be attained with the minimum of equipment.

NAME AGITATOR - ORE - 100 TON. | DRAWING / PART LIST | 0715

WHERE USED | DESCRIPTION | DATE | 1-25-29

MODEL	ASSEMBLY	
XD	9700	(2) STRENGTHENED FOR EXTRA HEAVY DUTY
		PIPING - 2 CHANGD FROM 7" HEAVY TO 7" EXTRA HEAVY.
		PIPING - 9 CHANGD FROM 7½" HEAVY TO 7½" EXTRA HEAVY.
		CASTING - 19 CHANGD FROM C.I. TO STEEL.
		PLATE - 38 CHANGD FROM ⅜" TO ⅝" THICKNESS.
		BEAM - 39 CHANGD FROM W.P. TO ASH. Brown
		CHECKED Hill.

RECOMMENDED DISPOSITION STOCK		
Auth. P.S. #215 CLASS "C" CHANGE.	REQUESTED	Jones.
	AUTHORIZED	Smith
	APPROVED	OPH
	APPROVED	

DRAWING AND PART LIST CHANGE NOTICE

Fig. 1—Form for recording changes to drawings

Cabinets Are Aid to Filing Prints

In filing blueprints, regular letter file cabinets may be used, bearing in mind that the prevailing commercial sizes are for papers 10 inches x 11½ inches and 10 inches x 15 inches. If the smallest blueprint size will file directly in this size, the next larger size can be filed by a single fold, the next by a double fold, etc. Large size blueprints should be folded first along their length like an accordion, then across their width as required. This is advisable in order that any point of the blueprint may be conveniently examined without the necessity of first having to spread out the entire blueprint on a flat surface. Folding takes care of this.

Where uniform size sheets are absolutely out of question, pigeon hole files for rolled tracings are commercially available in depths of 31 inches, 34 inches, 40 inches and 45 inches, which correspond to the widths of the drawings. Vertical plan files with a depth which will take any drawing up to 70 inches, and widths varying in increments of 3 inches to 6 inches from 11 inches to 48 inches also are available.

While the foregoing may seem like an undue emphasis on the ramifications of drawing size sheets, it should be borne in mind that their selection represents a decision which, if properly made at the beginning, will never require further consideration. Carelessly made, it is a source of constant argument and difficulty. In addition to the outside size of sheets, standard margins should be determined. Half-inch margins are recommended for all sizes except the left hand side, which should be 1½ inches to allow for binding whenever it is desired to bind the blueprints of a given job in a set for special reference purposes in the field or office. On very large general tracings subject to a great deal of blueprinting, it may be advisable to make the right hand margin 4 inches, to take the wear and tear

of frequent feeding into the blueprint machine for printing.

Except for the largest size sheet which may be of varying length and rolled for filing, printed sheets are recommended. A great deal of time is saved by printing the border, title block and alteration column headings on the standard size paper or tracing cloth sheets. It is false economy to crowd the title block or alteration column headings on the standard sheets as legibility is greatly aided by leaving enough room for reasonably large lettering.

Dimensioning on drawings should in general follow the commercial practice of the industry for which the drawings are made. To be properly "shop wise" these dimensions should be so placed as to be most convenient to the shop man, and in the form in which we would use them. It is far easier to convert calculated dimensions as obtained by the draftsman to shop dimensions as they will be used, once and for all on the tracing, than to have each shop man do so each time he uses the blueprint. Keeping dimension figures outside the body of the part drawn, making them large and also sufficiently heavy when blueprints are made directly from pencil tracings, appear almost too obvious to mention, yet they are too often a source of difficulty not to warrant a word of caution. If feasible, confining all dimensions to inches with the inch marks omitted and a note printed over the title block, "All dimensions in inches unless otherwise noted," is good practice.

Tolerances are really a part of any dimension. They are handled best by establishing standard tolerances for each class of work, to be noted just above the printed title block with the phrase "except as noted."

Special tolerances should be noted alongside the dimension figure they relate to. In a general way, dimensions with fractional tolerances should be expressed in fractional form while those with decimal tolerances should be expressed decimally.

A Good Close Tolerance Rule

Where close tolerances are required a good rule is to express the desired dimension decimally with plus or minus tolerances. In this way the workman aims at the desired figure. The selection of proper tolerances on a drawing, really deserves a great deal more consideration than it is sometimes accorded. Playing safe by the draftsman, by making the tolerance "plenty close" is a prolific source of waste due to unnecessary shop costs.

In these days of high speed production, lettering is significant chiefly in the fact that it should

NOTIFICATION OF ENGINEERING CHANGE

Date September 10, 1929.

To: Production Dep't.(Schedule Sect.)
Via: Assistant Chief Engineer.

Name of Project Lubricating Oil Tank Schedule No. 53-29

Nature of Change Redesign

Reason for Change Relocated 15° aft. due to change in equipment installation.

Drawings Affected 3406, 5417, 23010

Date of Release of Information September 21, 1929

Remarks New drawings required of tank, sling fittings and relocation of oil radiator

Copy to:
Planning Section
Ass't.to the Manager

(Signed) J. P. Russell

Fig. 2—Notification form used for advising all departments concerned in changes in design

be clear and legible. Notes should be expressed in simple language which will be clear even to the shop man of limited education. In certain fields, where the drawing is often used to sell the job to a nontechnical customer, as in architecture, it may be advisable to spend the time necessary to beautify the drawing with fancy lettering, however, in general this should be taboo. Vertical or slant lettering, capitals or lower case, are only vital in that there is an appreciable gain in appearance by adopting one or another and using it in accordance with established rules.

System for Recording Changes

Changes to issued drawings, their proper incorporation, recording and issue, are worthy of the best organizing effort of the design department executives. Changes originate from many sources, among which may be briefly cited (a) customers request; (b) design revisions; (c) improvements as a result of tests or other laboratory investigations; (d) discovery of errors in shop; (e) discovery of errors in design department; (f) incorporation of general instructions or technical orders on specific projects, and (g) improvements to reduce shop fabrication costs, etc. To many a draftsman, a particular change may appear so trivial that he feels there is no point in reissuing a drawing, and that merely changing the tracing and returning it to file suffices. *This is an entirely erroneous idea*—no matter how small the error corrected or the change may be, if it is worthy of being made, it must be made, recorded and issued in accordance with the system. A drawing change is not a personal matter concerning the individual or even the design department alone—it is the business of the entire organization.

Alterations to drawings, except those correcting obvious or minor errors, are best made upon written authorization, either in the form of a

project engineer's slip, customer's letter or general order. In addition to a proper though brief description of the change, such authorization should contain information as to the number of units the change is to be effective on recommendation for the disposition of the material affected by the change and any other special information. Where changes authorized do not affect the drawings, but merely salvage or accept material which fails to pass inspection through shop errors, they should be sent to the chief draftsman for information only and not for action.

F. 604. 2M. 9-28

ENGINEERING DEPARTMENT CHANGE NOTICE No. 55

Authorized by: Conference Feb. 14, 1928

Name of Part: Valve casing

Part No. 6125 Section Valve Model F-KF

DELIVER COPIES TO

X Purchasing	X Machining
X Assembly	X Mach. Inspection
X Inspection	X Service Dept.
X Engineering	X Stores

Design of casting changed to allow for pins as stops in place of cast stops for valve operating levers.

X Other Parts Changed: 6701 - 928 - 6128

EFFECTIVE:

——As soon as these parts can be obtained.
——Upon receipt of New Style Part No.——
——On exhaustion of present stock.
X On exhaustion of present rough stock.
——Simultaneously with change in design of even date on Part No.——

Model	Serial No.	Lot No.
KF		
F		

ASSEMBLY DEPT.:

X Notify Engineering Dept. Serial No. and Lot No. on which this change becomes effective.

——No record of Serial No. and Lot No. on which this change becomes effective needs to be made.

SERVICE DEPT.:

X New style parts may be used for machines using last previous design.
——Erectors to be notified.
——For repair parts furnish.
——All owners of Model ——Machines from No.——to No.——to be furnished with new part or parts {——gratis / ——at our cost.
——Recommend desirability of new part or parts to all present Model——owners from No.——to——

PATTERNS, FIXTURES & DIES:

——Requires New——Die——Pattern——Fixtures.
X Requires Change in——Die—X Pattern—X Fixtures.
——Request specially marked Blue Print for above.
——Old Number on——Die——Pattern——Fixtures.
——Changed to No.——

FINISHED PARTS:

——Change to new style.
——Allocate as Part No.——
——Request Special B. P. for changing.
——Hold quantity for repair orders.
——Place balance in special scrap.

X PARTS IN PROCESS X ROUGH PARTS—RAW MATERIAL

——Change to new style when machining.
——Request special Blue Print for machining.
X Can be used up.
——Hold quantity for repair orders.
——Place balance in special scrap.

PURCHASING DEPT. ONLY:

——These instructions supersede all preliminary notices.
——Final samples must be approved before proceeding with production.
——Call attention to this change when placing next order.
——Furnish revised certified blue print to manufacturer.
——Order small quantity to avoid loss if further change is desired.
——Cancel quantity now on order.
——Substitute new specifications for balance due, if possible.
——Parts in process to be changed.
——Raw material is changed from ——— to ———

The above is in accordance with Blue Print certified:

Feb. 14, 1928

Signed O. S. B.

Approved B. H. F.

Fig. 3—More comprehensive form used for recording design changes, disposal of rough or finished parts, etc.

Witness Number on Drawing and Change Notice

In making changes on drawings it is customary to fill in a witness number, the date and a brief synopsis of the change in the alteration column on a drawing. This information is best condensed so that it occupies but a single line for all changes of the same issue and date. Unless the number of changes is so great as to make it impractical, the same witness number should be placed in the body of the drawing, alongside of all dimensions, views, notes, quantities, etc. changed. This same witness number should also be used as a tie-in on the change notice form.

Changes Should Be Recorded on All Drawings

A change notice form as shown in Fig. 1 should be written for each drawing affected. It is customary to print all information on change notice forms with drawing ink, so that blueprint copies may be made and the original filed. Some concerns prefer to typewrite these forms, making either sufficient copies on the typewriter, blueprint machine or mimeograph machine. A clear synopsis of the change should precede the detailed information on the change notice form. Where practical, all parts, details, etc. affected should be specifically mentioned in describing the change. Unless the system of preserving a blueprint of a drawing before a change is made is in vogue, the changes should read "Changed from ——— to ———."

One of the most important functions of a change notice is to give information on the incorporation of the change on existing material. Omission of this information makes a change notice practically worthless to anyone outside of the design department. This information is best conveyed by means of a standard classification of changes, which for example may be:

Class A. Effective at once. Parts must be scrapped and standard parts salvaged.

Class B. Effective at once. Parts to be reworked as specified.

Class C. Effective after run out of parts on hand, in process or on order.

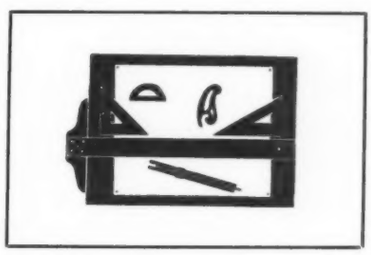
Where the revision of a drawing involves several classes of changes, a separate change notice should be made out for each class of change, but they should all bear the same witness number

and date as the alteration column of the drawing. Reference should also be made on the change notice form to all authorizing correspondence.

Changed drawings and change notice forms should be checked and issued in the same manner as was the original drawing. Where changes affect future work only, they may be made at the option of the chief draftsman, provided the authorizing letters or projects slips are properly kept track of, in case of a repeat order. All changes affecting work in the shop should be made immediately, otherwise a notice of engineering change, as shown in Fig. 2, should be issued. Changes should be automatically distributed to all departments—production, inspection, stores, etc.

Keep the Salesman Informed

Much is to be gained by meetings for discussion on development of design between representatives of sales, engineering and production. If the salesman, designer and production man work together, study their product and exchange ideas, the salesman will often be in a position to tell the customer what he wants before he knows it. If the customer insists upon changes being made, the well informed salesman will turn these proposals in the direction of his company's capacity and policy. Reasonably informed, the salesman can avoid those glib promises, carelessly made, the fulfillment of which are the bane of every designer and production man's existence.



The production man can bring to these sessions that intimate practical information, which properly considered at the inception of a design, can do so much to eliminate the unnecessary production hardship so often unthinkingly introduced by the designer. Where difficult production problems of necessity must be introduced and are unavoidable, the production man has ample time due to his advance information to scheme out a proper solution, rather than to depend on a spur of the moment happy hunch when the design is released for production.

The designer will gain first hand information concerning the customer's requirements, as well as the practical working capacities of the shops. He will also gain valuable information concerning accessibility for servicing his designs and their adaptability for easy replacements and repairs. More than all this in a sense, will he gain by the inspirational value of such contacts, in a newer appreciation of his effort as something which has a far reaching effect on industry in many fields and vast territories, rather than merely being something which is transposed to paper and thus ends as far as his experience with it is concerned.

To these meetings and their utility, a great deal can be added by calling in specialty engineers on occasion. The specialists' advice in relation to materials, parts and machine equipment is of inestimable worth. The material specialist not only can provide detail information as to the design values of his material, but he also can give information as to how this material can be most efficiently worked in the shop. By his intimate contact with the users of his product in other fields, the specialist can suggest applications of merit which might never occur to the designer. The parts specialist can introduce parts whose manufacture is beyond the capacity of the concern's own shops, or at a price which is far below the firm's own manufacturing costs for such a part. The machine equipment specialist can release for available design, processes and operations which on present plant equipment are impractical or impossible. Thus all three classes of specialty engineers are really the allies of the designer.

To properly foster research, there is a real need for a design library. True research begins where existing information leaves off. Maximum advantage should be taken of all existing data on a given subject, before further research is initiated. There is no point in continually affirming that which is already known and established. Due to the complexities of modern machine design, that which is already accomplished can only be ascertained by proper reference to catalogs, data, text books, journals and magazines.

Library Index System Important

The strength of a design library is measured by its indexing system. Data on library shelves have no value per se, except in as much as they are readily available. Information should be indexed not merely by its titles, but through critical reading by the librarian, so that it can be referenced and cross referenced by all possible subject headings. Much can be gained by anticipating the need for technical information, so that the librarian can have ample time to search out all possible leads. Current magazines and journals should be routed for circulation to all those who may be interested in the information in general, or who would be known to be interested in specific articles. Properly administered, encouraged and utilized, the library is a prolific source of design and research information.

Do Linestart Motors Necessitate Changes in Design?

By E. W. Henderson

DUE to the fact that there have been many conflicting reports about line-start motors and that, occasionally, trouble has been experienced in their application to machines, the author of the accompanying article has summed up some of the advantages and disadvantages of such motors; their starting and running performance as compared with standard motors; and their general overload and torque characteristics. The information given will be invaluable to chief engineers, designers and others who are contemplating the use of these newer type motors.

MOTORS designated "line-start," "switch-start," "across-the-line," and by other such terms, to indicate that these motors may be thrown directly across the line, have been placed on the market in the last few years. No intermediary starting or control device is used to reduce the voltage applied to the motor during the starting period. Instead, the motor is started by applying to it full line voltage. There must necessarily be some switch device through which such a motor is connected to the line and this usually takes the form of contactor switches operated through push button control. The point of difference between the newer type of induction motor and the original standard motor is, as the name indicates, that whereas the original or older type motor was started by applying to it a voltage less than the full line value, these are started on full voltage. The tendency of certain motor users to simplify control or reduce cost by throwing standard motors directly across the line, and the consequent insistence from power companies that starting currents be limited to as low values as possible, has been the chief reason for the introduction of the new type motor.

The starting current of across-the-line motors is less than of standard motors of similar rating. This is their chief advantage. They are provided in two classes: (a) normal torque motors, and (b) high torque motors. As the name implies, normal torque, across-the-line motors are intended for applications similar to those for standard motors. High torque motors are intended for applications demanding a higher-than-normal starting torque. They are often referred to as N.E.L.A. motors because in 1923 the National Electric Light association proposed limiting values of allowable starting currents for induction motors. These proposed values, through constant reference by power companies, utilities, manufacturers and others have become something of a standard. The starting currents proposed are tabulated in Table I. The figures appearing in the right-hand column of the table are not part of the table proper, but are shown to indicate the relative currents allowed under this proposal.

Starting currents given in the table apply to three-phase, 60 cycle, 220 volt motors. The starting currents for other three-phase voltages are inversely proportional to the voltage. The values for two-phase motors are 86.6 per cent of those of the three-phase motors of equal voltage and horsepower.

Machine design is not affected by the use of *normal torque* across-the-line motors. Their performance in all main particulars follows very closely that of standard motors. On the larger sizes the maximum, or pull-out torque is generally lower than that of standard motors, so that if extreme overloads are expected, the matter should be referred to the manufacturer. The pull-out torque of across-the-line motors is never less than 200 per cent but is not as high as that of low-slip standard motors, which often run over 300 per cent of full-load torque.

The starting torque of normal torque, across-the-line motors is equivalent to that of standard motors except where standard motors are started

through the lower voltage taps of starting compensators or transformers. For many applications a starting torque of the order of full load torque is necessary. This is especially true where the bearings of machines at rest lose their film of lubricating oil, so that the starting effort required is equal to or greater than full load running torque. Cold weather aggravates such cases and may cause abnormally high starting torque demands.

With this in view, motor designers have always taken into account the necessity of high starting torques into account the necessity of high starting torques and have so designed standard motors that when started through compensators, their starting torques will be sufficient.

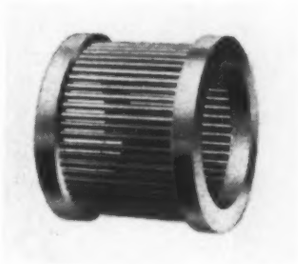


Fig. 1—Squirrel-Cage rotor winding

TABLE I

Horsepower	Starting current, locked rotor 3 Ph., 220 V., 60 Cy.	Amperes per horsepower
3	60	20
5	86.6	17.3
7½	116	15.5
10	141	14.1
15	197	13.1
20	250	12.5
25	304	12.15
30	360	12.0
40	380	9.5
50	400	8.0
100	800	8.0

A compensator is used for the purpose of reducing the current taken from the line during the starting period of the induction motor. It is essentially a transformer, and by reducing the voltage applied to the motor at starting, it reduces the current taken by the motor. Unfortunately, it also reduces its starting torque, and the designer must take this into account. Table II indicates the relative reduction in current and torque to be expected with the standard compensator. (The left hand column of this table represents the value of torque and amperes under full voltage starting. The other figures represent comparative values of torque and current when the motor is started under conditions represented by the different taps.)

For example:

Standard 30 horsepower motor, rated 440 volts, 3 phase, 60 cycle, and operating at a speed of 1800 revolutions per minute;

Full load current=40 amperes.

Full load torque = 90 pounds at one foot radius.

Full voltage starting torque = 200 per cent of full load torque = 180 pounds at one foot radius.

Full voltage starting current = 700 per cent of full load current = 280 amperes.

The figures given in the foregoing example used in conjuction with the figures given in Table II, show that if started on the 80 per cent tap, the motor will draw from the line 448 per cent of full load current (179 amperes) and develop 128 per cent of full load torque.

The across-the-line *normal* torque motor of 30 horsepower rating has a limiting starting current of 180 amperes and will develop a starting torque varying from 125 to 160 per cent of full load torque. Therefore the starting characteristics are practically identical.

Were the *high* torque across-the-line motor of 30 horsepower rating used, the starting current would be within the same limiting value of 180 amperes, but the starting torque would be about 250 per cent full load torque, so that where such a motor is used, care should be taken as to the ability of the load-connecting belt or chain to withstand the shock of this starting effort.

Pulley dimensions for power motors are standardized by the National Electrical Manufacturers' association according to speed and horsepower. They are fixed indiscriminately for direct and alternating current motors. The constant-speed shunt motor, when starting, takes approximately 150 per cent of full load current and develops a starting torque of approximately 150 per cent of full load torque. Therefore the starting current of this motor is ordinarily less than that of the corresponding induction motor; but the torque of the across-the-line motor is practically identical with that of the direct motor, varying,

TABLE II

Compensator tap or percentage full line voltage applied to motor	100	80	65	50
Current taken from line	100	64	43	25
Starting torque	100	64	43	25

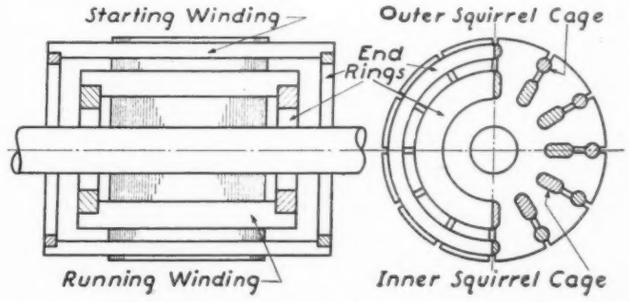


Fig. 2—Double squirrel-cage rotor, showing the two short-circuited windings

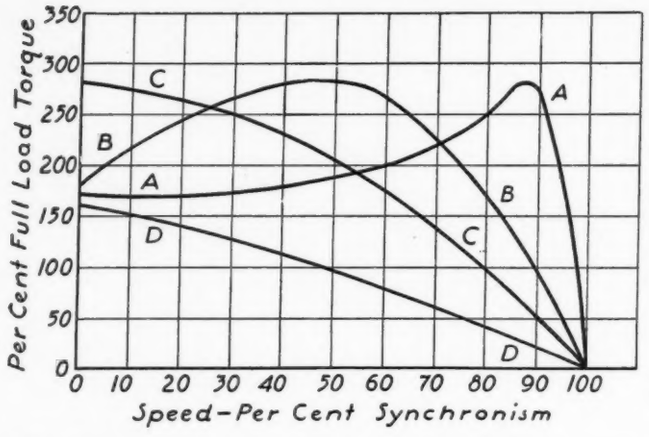


Fig. 3—Torque characteristics of standard motors. A, standard low slip; B, semi-high torque; C, high torque; D, effect on torque of high resistance rotor

as it does, from 125 to 160 per cent of full load torque. Inasmuch as these pulleys and corresponding belt sizes are adequate for direct current motors and standard induction motors on 80 per cent taps, and have overload capacities exceeding 200 per cent, there should be no trouble from their use on across-the-line *normal torque* motors. Where trouble from belt or chain damage has occurred, it has generally been due to the use of standard equipment with *high torque* motors.

Time Lag Reduces Starting Torque

The starting torque of the standard type low-slip squirrel-cage motor is less than its pull-out value because at starting, there is a time lag of the current in the rotor bars behind the primary flux, so that the torque which is due to the reaction between this primary magnetic field and the rotor current-carrying conductors, is reduced below what it would be were current and flux in phase. The torque characteristics of the standard motor are shown in Fig. 3. Referring to curve *A*, as the rotor starts from rest and comes up to speed, the current decreases, but up to the point of maximum torque this drop in current is more than offset by the betterment of time phase relation between flux and rotor current, and the torque is increased. Beyond the speed of maximum torque the reduction in rotor current more than offsets the phase relation advantage and the torque decreases, becoming zero at synchronous speed.

If another rotor having higher resistance is used with the original stator, the torque curve may be represented by curve *B*. The rotor resistance may be increased to such a value as to give the torque curve illustrated by curve *C*, where the starting torque becomes equal to the pull-out torque. If the rotor resistance is increased beyond this point, the starting torque is reduced and will follow along a curve such as *D*.

Since the use of the double squirrel-cage rotor is common its action is worthy of note. As the name implies, it consists of two squirrel-cage short circuited windings. One having a high resistance, is placed near the rotor surface. The other having a low resistance, is placed in slots well below the surface of the rotor, as shown in Fig. 2. The two circuits form parallel paths for the rotor current. The frequency of the rotor current varies from line frequency at standstill, to zero at synchronism. It is proportional to the slip. The reactance of the inner, low-resistance winding is inherently high due to the fact that the winding is buried in the iron core. Thus, of the two windings, the impedance of the upper winding consists chiefly of its high resistance, this resistance being constant. The impedance of the lower winding consists almost entirely of its reactance, and this reactance varies inversely with the rotor speed, being highest at starting, and small at running speed. Thus, at starting, the high reactance allows but little current to flow in the lower winding. The current is forced to flow through the high-resistance outer winding, and the resulting starting torque is produced mainly by this winding. As the motor speeds up the reactance of the lower winding decreases, the resistance of the upper remains constant, so that a greater and greater proportion of the total current flows through the lower winding until under running conditions practically all of the current flows through the low resistance winding. The motor, therefore, has low slip and good efficiency. The burying of the lower winding in the rotor core has the effect of reducing the pull-out torque and lowering the power-factor slightly. These are its chief disadvantages. However, across-the-line motors built with double squirrel-cage rotors generally have in excess of

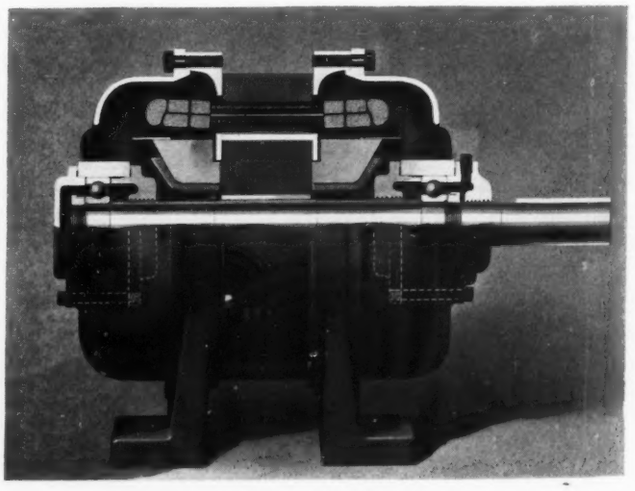


Fig. 4—Cross-sectional view of ball bearing squirrel-cage motor, riveted frame

200 per cent pull-out torque, so that little trouble may be feared on this score.

Fig. 6 shows characteristic torque curves of across-the-line, double squirrel-cage motors. By comparing Fig. 3 with Fig. 6, it will be seen that the main difference between the standard motor and the normal-torque across-the-line motor is in the value of maximum or pull-out torque. The starting torques are very similar.

Summing up, across-the-line motors of the motor are shown in Fig. 1. Referring to curve *A*, smaller sizes are the equivalent of standard motors in practically every respect and have the advantage of decreased starting current. Motors of the larger sizes have the advantage of reduced starting current but have the disadvantage of slightly reduced pull-out torque and power factor. One of the chief results of the use of across-the-line motors will be the spreading of the idea of throwing standard motors across the line. Many companies do this now. The disturbance of throwing a standard 10 horsepower motor across the line is considerably less than that caused by a 50 horsepower motor started through a compensator. The tendency will be to have the present limits raised so as to permit of standard motors being so used. If the purchaser of a standard motor wishes to throw it across the line, he should so specify on ordering as it may involve the necessity of bracing the coil ends to prevent movement by forces of starting current.

The cost of across-the-line motors is slightly higher than that of standard motors. However, the cost of the across-the-line type motor together with that of the starting contactor switch with push button control is less than that of the standard motor and starting compensator. The saving varies from 6 per cent to 32 per cent depending on the rating. The efficiencies of the

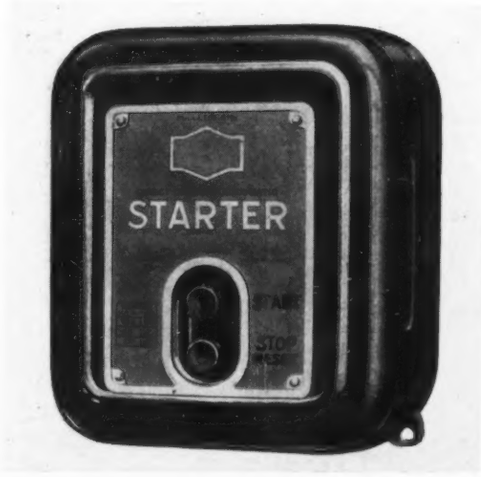


Fig. 5—A type of control for linestart motors, showing the pushbutton switch

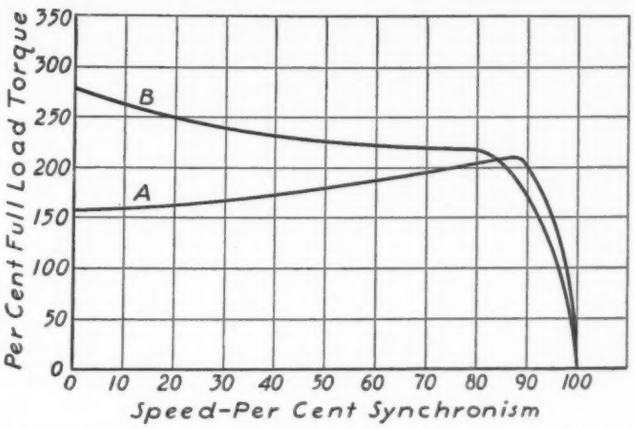


Fig. 6—Torque characteristics of across-the-line motors. A, normal torque; B, high torque

two types are practically identical so that the power requirements are equal and the cost of operation identical. The pull-out torque of the line-start motors is ample. The speeds under load are practically the same. Where single cage rotors are used, the power factors will usually be as high in the across-the-line as on the standard motor. Where double-cage rotors are used the power factor will be slightly lower on the line-start motors. From the economy of the cost of installation of motor and controller and also decreased maintenance, in favor of the line-start motor, this latter type has somewhat of an advantage over the standard type with a compensator. Over the standard motor thrown on the line it has no advantage save a decreased starting current.

Discusses Hydraulic Speeds and Feeds at Engineering Congress

Advantages and disadvantages of the hydraulic feed were discussed in a paper by A. L. DeLeeuw, consulting engineer, Plainfield, N. J., at the World Engineering congress which opened in Tokyo, Japan, October 29. Of interest to designers are the following points raised by Mr. DeLeeuw:

Amount of feed can be varied by infinitesimal steps between the maximum and minimum required by the machine.

The feed is not subject to the irregularities caused by the action of gear teeth or by the spring of shafts in an ordinary mechanical feeding device, and as a result it produces a smoother finish.

The device can be, for the greater part, outside of the machine, so that in its very nature it can be applied as a unit to any machine, whatever its kind or style, though, of course, for economical reasons, one would naturally use a few sizes of pumps for various sizes of machines.

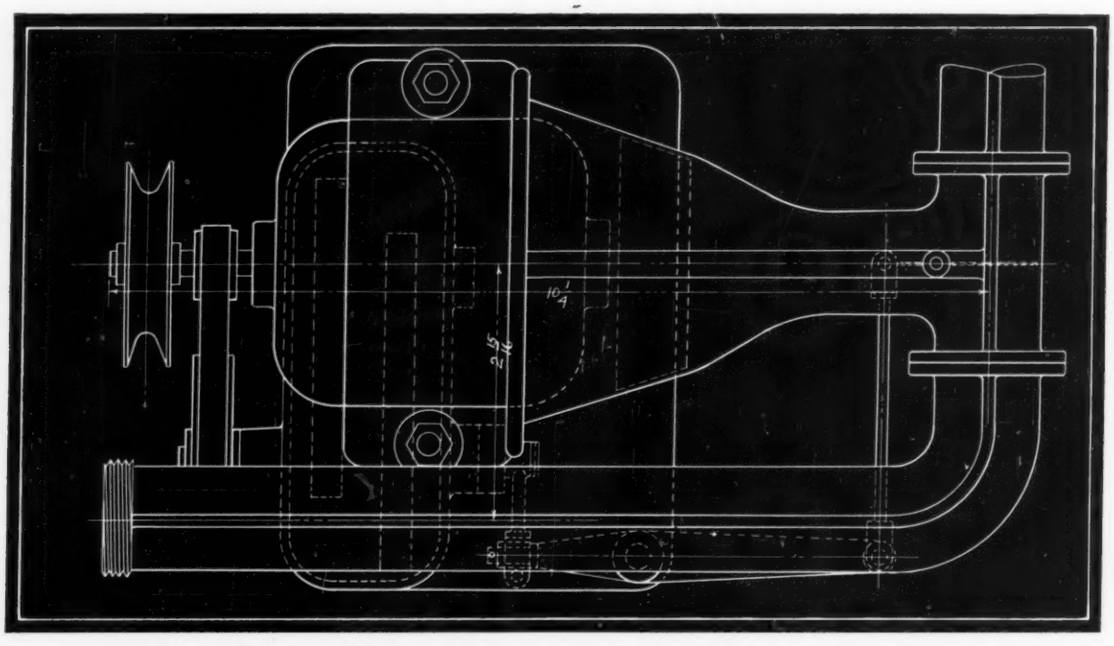
How Correct Drawings Save Time, Money and Effort

By Glen Macomber

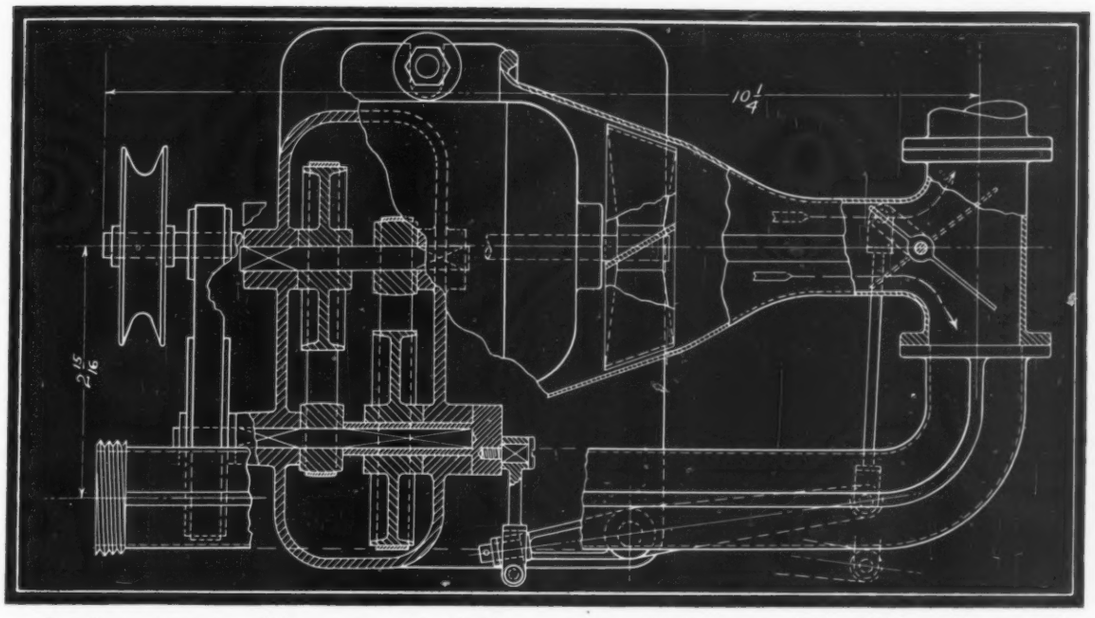
AS A noted author once wrote: "Let Virgil sing the praises of Augustus; the short and simple annals of the poor shall engross my pen;" and, to bring the paraphrase to date, "Let the handbooks of the engineers sing the praises of stresses and coefficients—the short and simple annals of the correct mechanical drawings shall engross my ruling pen." It is comparatively easy to find, in a thousand and one rules, as well as experience, the secrets governing successful machine design and to apply these in working out the problems of a new piece of machinery; but how to convey the mental image of these new creations to the brain of the machinist or the purchasing agent and others who have occasion to refer to the drawings is an important phase of the question which seems to have been overlooked, at least as far as practical application is concerned.

I once knew a machinist who spent two whole days reading a set of drawings that he could have mastered in one hour if the draftsman had put in the necessary amount of illustration. A drawing made correctly and fully illustrating all the necessary points in a way that they can be recognized easily, is a great time saver all the way through for those who have occasion to read it. This applies especially to assemblies and general drawings.

For every dollar spent in making a drawing there are a good many dollars spent on the part that it portrays; so why not make it clear cut, exact, concise and complete? Detail drawings should show all of the views and cross-sections necessary to convey the idea without question to the reader, and dimensions should be placed where one would expect to find them. Important dimensions placed in obscure places do not make for efficiency; they cause unnecessary loss of time in searching for them. All dimension lines should be kept far enough away from the subject of illustration to be easily identified. That is, the detail should look like a detail and not like a will-o-the-wisp hiding among dimension lines. Drawings last sometimes for a good many years—I have worked from drawings twenty



Drawing in which the main features of mechanism are obscured



Same mechanism drawn with cover, etc. broken away. Note ease with which action of details can be followed

years old—and if each person who refers to them saves a few minutes or hours it ought to be easy for efficiency experts to figure out that a good drawing saves a lot of time. It is also a creater of good will as well as efficiency, for it makes it possible for the machinist to concentrate his efforts on the cutting of metal instead of attempting to read some one else's mind.

This is good advice for a designer or draftsman to follow: "Do not imagine that other people are mind readers." Mind reading is amongst the possibilities, there is evidence to believe; but mind reading acts are much more successful in a vaudeville performance than they are in a machine shop or factory. The mechanic's attempt costs the manager or owner a lot of money. He has to pay for the performance—and does not get box seat, either. If the draftsmen only had transparent heads and could be put on file with the blueprints—what a help that would be!

Many Factors To Be Considered

Layouts, assemblies and general drawings often fail to measure up to the desired standard of clearness for the reason that there are a lot of factors to be considered. All the details are collected together on one sheet and a lot of them have the faculty of hiding themselves. I have before me an assembly made by one of the largest and oldest factories in a certain city of the United States. It is a beautiful piece of work judged from the standpoint of neatness; but upon trying to understand this assembly I find myself in a quagmire of uncertainty. The draftsman has followed to a conscientious degree the placing of each line and circle; he has included a reference figure for each detail, all as per the rule; but the most vital part of the machine, that part in which the reader is the most concerned, is hidden behind a piece of plain iron and the intricate details are completely lost in a meaningless maze of dotted lines. The parts in question do not appear on any of the other views; consequently there is no way to ferret them out.

Vital Parts Should Be Visible

What the draftsman should have done in the above case was to break away the meaningless piece of cast iron and show the vital parts in their true and proper visibility. Also, he should have included them in the other views so that the reader could check across from one view to the other. To take a multitude of details, assemble them together on a single sheet and get them to come out from their obscure hiding places and disclose to the eye the real shape, size, construction and *movement* is not an easy task. It can be done, however, with proper concentration on the subject. The main rule for assemblies should be: Show the machine and show it completely; put in all of the anatomy. One important way to do this is to break away the intruding portions. Break open the housings and show the gears; break away the frame and show the "innards," use the axe freely where it will clarify matters. A pulley with several spokes broken out or an electric motor slashed across with a ruthless hand are good things if they help to put the machine across. Above all, make it a point to show the motion.

Adopt Recommended Practice for Herringbone Gears

INCREASED employment of herringbone gears in numerous branches of the engineering industry, is centering attention on this type of gear. For this reason certain proposals of the American Gear Manufacturers' association covering recommended practice for herringbone gears, are of timely interest to designers. These proposals were outlined at a recent meeting of the gear manufacturers' association by A. A. Ross, chairman of the herringbone gear committee of the association and the proposed practice was adopted by the meeting as an aid toward the later formulation of a definite standard.

It was the original intention of the committee to limit the helix angle, pressure angle, etc. to definite values, but this was found to be impracticable because satisfactory herringbone gears at present are being cut with helix and pressure angles varying through a wide range. The proposals therefore were limited in this respect to recommendations that the pressure angle, in plane of rotation, be between 15 degrees 23 minutes minimum and 25 degrees maximum, and that the helix angle be not less than 20 degrees or greater than 45 degrees.

The text of the recommended practice for herringbone gears as adopted in October, and superseding previous herringbone practices, is as follows:

1. A Herringbone Gear is a double helical gear, the helical angles of which are opposed.

2. Diametral Pitch and Tooth Proportion shall be known, referred to and calculated on the basis of diametral pitch in plane of rotation. For instance, if the teeth are cut with a standard spur gear hob the resulting fractional diametral pitch and pressure angle in plane of rotation shall be referred to and quoted without any reference to tooth proportions on the normal section.

3. In the following:

A = *Addendum*
AF = *Active Face*
B = *Backlash*
C = *Clearance*
CDI = *Center Distance*
D = *Dedendum*
DP = *Diametral Pitch in plane of rotation*
GD = *Groove Depth*
GW = *Groove Width*
N = *Number of Teeth*
OD = *Outside Diameter*
PD = *Pitch Diameter*
FW = *Face Width*
TL = *Tooth Load*
VP = *Pressure Angle in Plan of Rotation*
VH = *Helix Angle*
WD = *Whole Depth*

4. PD (Pitch Diameter) $= \frac{N}{DP}$

5. VP (Pressure Angle) in plane of rotation =
Maximum 25°
Minimum 15° 23′

Note: The maximum VP in combination with the maximum VH will result in a pressure angle of approximately 18° 15′ on the normal. The minimum VP given is the approximate resultant from 14½° pressure angle on the normal with the minimum VH.

6. VH (Helical Angle) = Maximum 45°
Minimum 20°

7. A (Addendum) = Maximum $\frac{1}{DP}$
= Minimum $\frac{.7}{DP}$

8. C (Clearance) = Maximum $\frac{.3}{DP}$
= Minimum $\frac{.157}{DP}$

NOTE:—If the Space Bottom (a line joining two fillets of adjacent tooth profiles in the same plane) is a curved concave recess tangent to the fillets of the adjacent tooth profiles, the clearance (C) shall be increased by an amount equal to the depth of the recess.

9. D (Dedendum) = A + C

10. WD (Whole Depth) = 2A + C

11. OD (Outside Diameter) $= \frac{N}{DP} + 2A$

NOTE:—If the pressure angle (VP) and helical angle (VH) are known and the pressure angle of the hob or of tooth profile normal to helical angle is desired then the tangent of that angle is equal to the tangent of VP multiplied by the cosine of VH. Likewise, if the pressure angle of the hob and helical angle (VH) are known and the pressure angle (VP) in plane of rotation is desired, then the tangent of that angle is equal to the tangent of the hob pressure angle divided by the cosine of VH.

If the Diametral Pitch (DP) and helical angle (VH) are known, the Diametral Pitch of the tooth normal to

the helical angle or that of the hob is equal to *DP* divided by the cosine of *VH*. Likewise, if the diametral pitch of the hob and *VH* are known, then *DP* equals the diametral pitch of the hob multiplied by the cosine of *VH*.

If *DP* and the diametral pitch of the hob are fixed then the cosine of *VH* equals *DP* divided by the diametral pitch of the hob.

12. *AF* (Active Face) shall be equal to the sum of the right and left hand helices measured parallel to the axis of the gear.

13. Minimum AF (Active Face) $= \dfrac{1.15 \times 2\pi}{\text{DP} \times \text{Tan VH}}$

14. *FW* (Face Width) shall be equal to *AF* plus space between helices.

15. *GW* (Groove Width) if any, between helices, shall be the minimum permissible on type of cutting machine and diameter of hob used.

16. *GD* (Groove Depth) if any, between helices shall as a maximum equal *WD* plus 1/32.

17. If it is desired to eliminate the undercutting of the hob the outside diameter of the pinion should be increased (no increase in *WD*) an amount equal to

$$2\text{D} - \frac{2\ \text{DP}}{(\text{Sine VP})^3 \times \text{N}}$$

18. If it is desired to simply obtain full involute action over the working depth of teeth between pinion and its mating gear, the outside diameter of the pinion should be increased (no increase in *WD*) an amount equal to

$$2\text{A} - \frac{(\text{Sine VP})^3 \times \text{N}}{2\ \text{DP}}$$

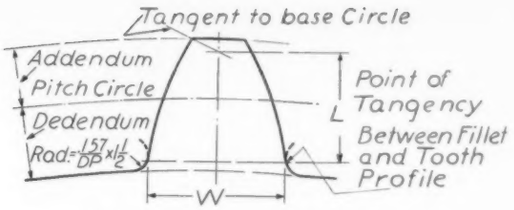
19. If the outside diameter of the pinion is increased and the theoretical center distance (*CDI*) is maintained, then the outside diameter of the mating gear must be reduced (no decrease in *WD*) a similar amount, but if the center distance can be increased, then increase it by one-half the increase of the pinion and makes no reduction in the gear diameters.

20. Backlash (*B*) is the shortest distance between non-driving tooth surfaces of adjacent teeth in mating gears.

Minimum Industrial Gears		Minimum High Speed Gears
DP	*B*	*B*
24	.002″	.003″
16	.002″	.003″
12	.003″	.004″
10	.003″	.004″
8	.004″	.005″
6	.005″	.007″
5	.006″	.008″
4	.008″	.010″
3	.010″	.013″
2½	.012″	
2	.015″	
1½	.020″	
1	.030″	

21. The ends of the teeth of each helix shall not be beveled except to remove cutting burrs.

22. Maximum *TL* (Tooth Load) per inch *AF* (Active Face) $= \dfrac{\text{Y} \times \text{S} \times \text{K}}{\text{DP} \times \text{P}}$



Section in Plane of Rotation

Y = Tooth Proportion Factor for 1 $DP = \dfrac{W^2}{6L}$

S = Allowable Static Stress of Material.

Material	*S*
High Carbon or Alloy Steels heat treated to an elastic limit of approx. 60,000 lbs. per sq. in.....	15,000
.40 to .50 Carbon Steel heat treated to an elastic limit of approx. 50,000 lbs. per sq. in.....	12,500
.40 to .50 Carbon Steel untreated with an elastic limit of approx. 40,000 lbs. per sq. in.....	10,000
Cast Steel A. S. T. M. Class B. Elastic Limit approx. 36,000 lbs. per sq. in.....	7,500
Cast Iron, Tensile strength approx. 24,000 lbs. per sq. in.	4,000
Bronze 88-10-2 Tensile strength approx. 27,000 lbs. per sq. in.	4,000

NOTE:—It should be noted that the teeth of herringbone gears are cut after the material is treated. Higher physical characteristics than those quoted above for steels may result in material too hard to cut.

22. K = Velocity Factor in feet per minute =

$$\frac{78}{78 + \sqrt{\text{Pitch Line Velocity}}}$$

P = Wear and Lubrication Factor.

For enclosed gears in which the viscosity and character of the lubricant is correctly chosen for the type of gear and service a P Factor of 1.15 is recommended.

NOTE:—The above formula gives allowable tooth loads for uniform and smooth operation but if operating conditions are such that either the driving or driven elements cause uneven or intermittent loads, then the tooth load should be reduced by a utility factor which can only be determined by actual experience in the particular class of service. It should also be noted that this formula is based on tooth proportions in which the pressure angle and L in the Y factor are such as will give 1.5 or more teeth in contact with (*LA*) the Line of Action (Plane of Rotation). If less than 1.5 the Tooth Load (*TL*) should be reduced.

Submitted to the Sectional Committee for the Standardization of Gears, composed of members of the A. S. M. E. and A. G. M. A., organized as sponsor societies under the procedure of the American Standards Association

The American Gear Manufacturers' Association will appreciate any suggestions or recommendations for the improvement of the above Recommended Practice.

MACHINE DESIGN

Esthetics in Machines

Editorial

ONE of the best tonics for engineers who are momentarily depressed by the repetition of knotty problems is to break away from the routine of the daily task and to browse for a few minutes in the history of engineering achievement. One cannot examine the blueprints and photographs of machines of the period of 1890 to 1915 without contrasting their design with that of modern equipment. Nor can one escape the conclusion that comparisons of this kind reveal striking evidence of the rapidity with which our ideas are changing.

THE early models give the impression that the designers were intent on solving only the fundamental mechanical problems. The first automobiles and the original airplanes indicate an intensive effort on the part of their creators to build them so that they "would run." Later on, the improved design and construction suggest that efficiency was the compelling motive of design. And finally, in the most recent models, we see refinements in mechanical detail and in outward appearance that connote a striving for beauty —beauty which is found in mechanical perfection, harmonious contour and decoration in good taste.

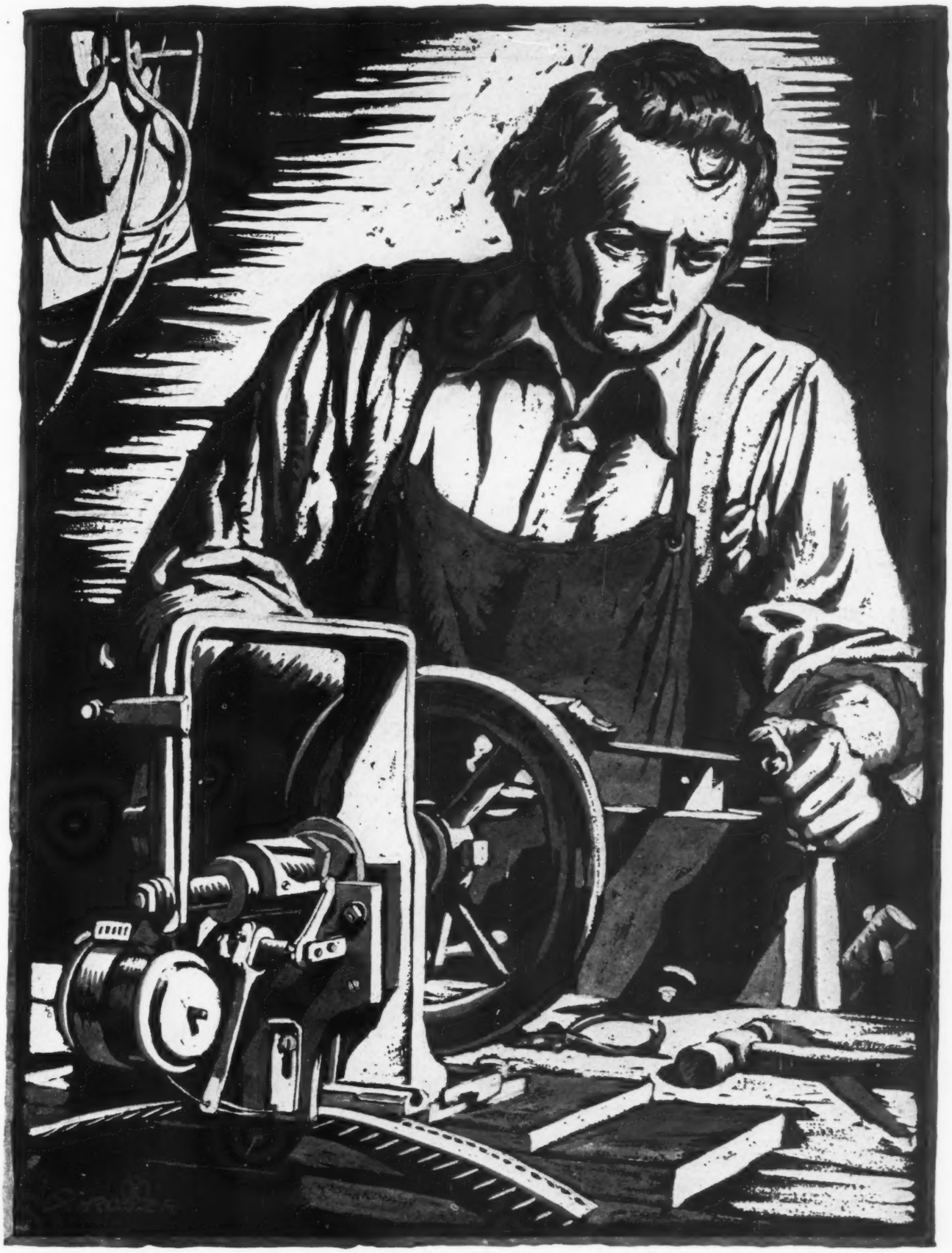
IF WE analyze these various steps in the development of machines, we find that they fall readily into three classes or stages. The first is the pioneering stage, during which the inventor is struggling solely with the immediate problems of mechanics. During the second period, the designer, having solved the problems of the pioneering stage, turns his attention to mechanical refinements. He seeks better materials, improved methods and more highly perfected parts with a view of increasing the efficiency of his machine.

THE third and final stage is that in which the engineer, while still seeking mechanical perfection, also strives for beauty and harmony in design. Many types of machines already are in this stage of development. Examples that come to mind are automobiles, some machine tools, washing machines, electrical refrigerators, and many other products. Airplanes are on the threshold of the last stage. Other machines, mostly for the manufacturing industries, are ready for the third stage, but thus far no concerted action has been taken by the engineering profession to hasten development in that direction.

THE design profession is in need of original ideas on beauty in machines. A study should be made of the relation of appearance to salability. Already there are signs that attention to the esthetic quality of design pays dividends in the more receptive attitude of prospective purchasers of machines. Those engineers who are alert to this impending trend, and who are prepared to meet it, will profit from their foresightedness.

Unit or Assembly

CONTINUOUS operation in American industry is gaining favor. The idea of feeding materials into a great machine and having them emerge as finished products, without interruption, appeals strongly to manufacturers whose appetites have been whetted by the success of mass production. This new passion for continuous processes is enlarging the field for engineers who specialize in the co-ordination and synchronization of machines. Thus far, their principal task in designing equipment for continuous manufacture has been to assemble a group of dissimilar machines of stock model and to revamp them so that they will operate in harmony as one large automatic unit. Perhaps we shall soon witness a change in design procedure. Is it not possible that progressive engineers in the future will consider the whole layout as one unit, to be designed as such from the ground up, rather than as the assembly, adaptation and co-ordination of separate machines?



Elias Howe and His Sewing Machine

Great Moments in Machine Design—Fourth of a series of original drawings prepared exclusively for this magazine symbolizing the designer's contributions to the progress of mankind

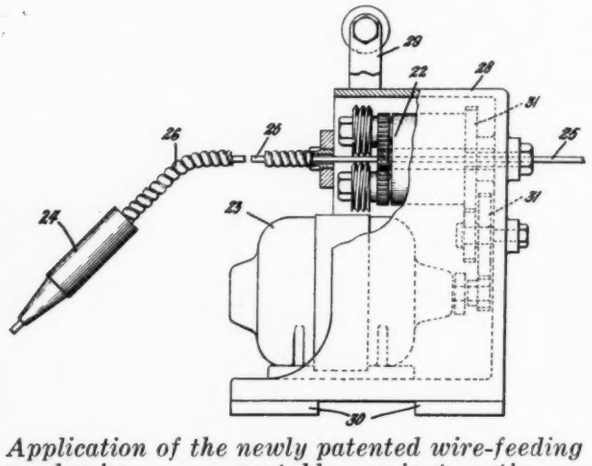
NOTEWORTHY PATENTS

A Monthly Digest of Recently Patented Machines Parts and Materials Pertaining to Design

A WIRE-FEEDING mechanism for automatic arc welding machines to feed an electrode forward and away from the work and to control the arc during the welding operation is the subject of patent No. 1,733,812 recently granted by the United States patent office and assigned by the inventor, Mungo L. MacRae to General Electric Co., Schenectady, N. Y. In metallic arc automatic welding machines where the electrode fuses rapidly and is incorporated in the weld, the inventor contends that it is desirable to provide the electrode in the form of wire of indefinite length, which may be drawn from a reel as it is used.

The object of Mr. Mungo's invention is to provide an improved wire-feeding mechanism which is claimed to be simple and effective and because it produces within itself an inherent speed reduction. Moreover, it provides a feeding device in which a threaded feed roll rotated about an axis substantially parallel to the line of wire feed engages the electrode wire and feeds it by reasons of the screwlike engagement of the two.

Means for rotating the feed roll about the wire being fed during the welding operation at a rate of speed capable of eliminating slippage between the electrode and the rolls are also incorporated in the device. An example of an application of the invention is shown clearly in the accompanying illustration. This is on a portable semiautomatic arc welding machine of the type described in United States patent No. 1,508,711, granted to Paul O. Noble and assigned to the General Electric Co.



Application of the newly patented wire-feeding mechanism on a portable semiautomatic arc welding machine

Comprising the apparatus shown are electrode feeding mechanism 22, according to invention described; a motor 23 for operating the feeding mechanism, a welding tool 24 to which an electrode 25 is adapted to be fed, and a flexible metallic tube 26 for guiding the electrode from the feeding mechanism to the welding tool. Motor and feeding mechanism are supported in the partially enclosed casing 28 provided with a handle 29 and a base 30. The base may conveniently be an electromagnet, which when excited will attach the casing to a magnetic supporting surface.

Gears May Be Eliminated

Motor 23 is shown connected to the feeding device 22 through gears 31, although it is understood that by aligning the feeding device with the feed motor and feeding the electrode through a hollow shaft, these gears may be eliminated. Motor 23 may be a variable speed unit connected so as to respond to characteristics of the arc which vary its length. Thus the motor speed is regulated with changes in the length of the arc in a manner to govern the rate of the electrode feed to maintain a constant arc length.

By connecting the motor across the arc it will be responsive to arc voltage. The voltage of an arc varies with its length and consequently if the arc tends to lengthen, then the voltage impress on motor 23 will rise, thereby increasing the speed of the motor, which in turn will feed the electrode at a more rapid rate to re-establish the original length of the arc. As the length of the arc shortens the reverse operation will take place. The wire feeding mechanism also can be adapted to a welding head where a constant-speed motor is used as the driving means and the rate of electrode feed is governed by a speed regulating means arranged between the constant speed driving means and electrode feeding mechanism.

To prevent rotative movement of the arm of

a radial drilling machine, David C. Klausmeyer has invented a telescoping arm clamp for which

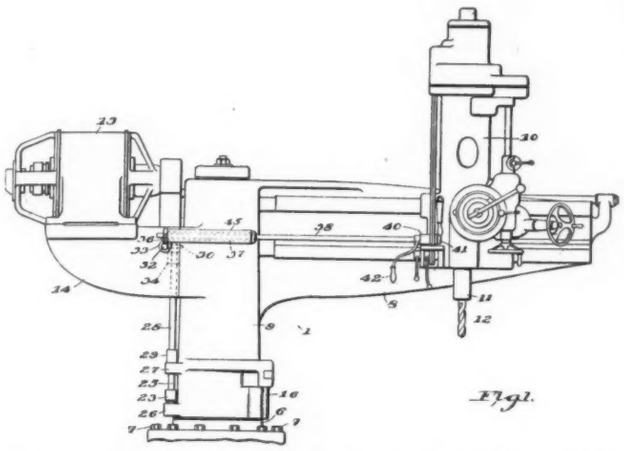


Fig. 1—Front elevational view of mobile radial drill equipped with clamping mechanism

the United States Patent office has granted him patent No. 1,734,523. He has assigned it to the Cincinnati Bickford Tool Co., Cincinnati.

In a radial drill, a post or column is provided for supporting a radial arm which is adapted to move rotatively about the post. A drill head which is mounted on and movable along the radial arm, carries a drilling tool. One of the principal features of Mr. Klausmeyer's invention is to provide improved means for clamping the radial arm against rotative movement when in an operative position.

In addition the invention provides means for controlling the clamping mechanism at a point adjacent to the drill head. When the drill head has been set in a predetermined position the arm must be firmly clamped against rotative action.

Fig. 1 is the front elevational view of a mobile radial drill having a clamp mechanism constructed in accordance with the described invention. Fig. 2 is a detail view of the clamping shaft. The clamping mechanism which is located on the sleeve portion 9, to the rear of the post, is operated from a point adjacent to the head 10. The shaft 25, which carries the eccentric for operating the clamping mechanism, is connected to the vertical shaft 28 by means of the coupling 29. The vertical shaft carries the pinion 30, which meshes with teeth 31 on a rack 32.

The rack 32 is slidably supported on the sleeve portion 9 by means of a bearing lug 33. Vertical shaft 28 is provided with a bearing lug 34 projecting from sleeve 9. A second set of teeth 35 on rack 32 mesh with the teeth formed on a gear segment 36. The gear segment is mounted upon the radial arm 8 and this has an elongated hub portion 37.

A clamping shaft 38 extends through the hub portion 37, as shown in Fig. 2, and has a spline connection with the gear segment 36. Hub 37 has a bearing in a lug 45 on the sleeve 9. Thus the clamping shaft and the gear segment are compelled to rotate together, while the clamping shaft is free to move axially with respect to the gear segment.

Provision is made for clamping the sleeve portion 9 to the post 6 in order to insure against any rotative movement of the radial arm 8 when in a set position. The lower part 16 of the sleeve portion 9 in enlarged to form a bell which is circumferentially cut. The bell 16 is also transversely cut to provide slightly flexible wings 19 and 20. The wings are provided with lugs which by means of a draw-bolt 23 (actuated by an eccentric 24 on the shaft 25 journaled in the parts 26 and 27) may be drawn together to clamp the sleeve portion against a post. Thus, by rotating the shaft 25 through a partial revolution the sleeve may be clamped or unclamped at will.

The clamping shaft extends along the arm 8 and has one end secured to the head 10. Shaft 38 projects through a hub 40 which is formed on the side of the head 10 next to the sleeve 9. A collar 41 is pinned to the shaft on the opposite side of the hub 40. Thus, by means of the collar 41 and the operating lever 42 the shaft 38 is compelled to move in accordance with the movement of the head along the arm. Lever 42 serves to rotate the clamping shaft for operating the clamping mechanism and thus control the clamping and unclamping of the sleeve portion 9 to the post or column. Although the operating lever 42 is out of the operator's way, still it is conveniently located so that the clamping operation may

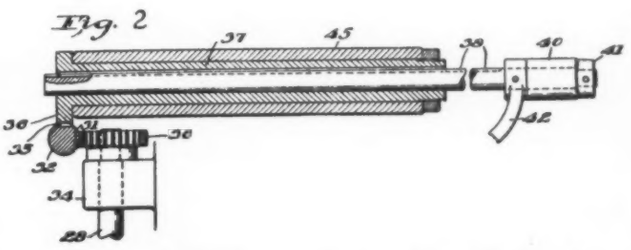


Fig. 2—Sectional view, showing details of clamping shaft

be effected without the operator changing his position after having set the head in an operative position.

Review of Noteworthy Patents

Other patents pertaining to design are briefly described as follows:

THRUST BEARING—1,735,315, for "a thrust bearing having a thrust element with a continuous and unyielding

rubbing surface and a co-operative thrust element divided into a plurality of shoes or sections having rubbing surfaces co-operative with that of said first thrust element and adapted to yield under the action of the load for the purpose of facilitating the introduction of oil between the cooperative rubbing surfaces." Assigned to Allis-Chalmers Mfg. Co., Milwaukee, Wis.

BRAKING DEVICE—1,735,139, for a device composed of "a backing plate, a pair of shoes having beveled ends, a rocking member pivotally mounted on the backing plate and extending inwardly from said mounting and disposed between adjacent ends of said shoes and having opposite parts movable toward or away from each other and engaging said beveled ends." Assigned to the Midland Steel Products Co., Cleveland.

FLUID PRESSURE MOTOR—1,735,176, for a rotary motor comprising "the combination of a cylinder, a rotor therein, a shaft extending through said cylinder and to which rotor is secured, said shaft having a bore for lubricant and a port extending from said bore to conduct lubricant to said cylinder, a fluid pressure conduit communicating with said cylinder, and a connection between said conduit and a supply portion of said bore thereby to equalize the pressure upon the said port and upon the supply end of the bore." Assigned to Rotor Air Tool Co., Cleveland.

TIMING GEAR—1,735,229, for the combination of a "power shaft, a gear upon the shaft, including interengaging inner and outer metallic rings fitted to permit radial movement, the inner of said rings having a flange and a hub portion, the outer having a recess adapted to receive the flange and a bore adapted to receive the hub portion." Assigned to the Willys-Overland Co., Toledo, O.

CHAIN LINK—1,734,960 for a chain link embodying a pair of link members each having a side portion and a laterally extending tubular portion. An inwardly tapered enlargement is provided in the bore of one of the members, the other member being adapted to be driven into the enlargement and to be spread laterally thereinto. The enclosing member extends to the side portion of the other member. Assigned to the Link-Belt Co., Chicago.

LUBRICATING COUPLING NIPPLE—1,734,996, consisting of "the combination of a conduit adapted to receive lubricant under pressure, a nozzle secured thereto and having a noncircular socket in its outer end, a coupling sleeve swiveled on said nozzle and having an end opening adapted to register with said socket, and a spring tending to rotate said sleeve to a position in which the opening in the end thereof is out of registry with said socket." Assigned to Alemite Corp., Chicago.

FLEXIBLE GEAR WHEEL—1,735,105, for "a flexible gear wheel comprising a center portion, a rim portion, stops provided on the center portion, a spring element and a retaining ring, said spring element comprising an annular spring member having a portion removed to provide faces for engagement with the stops provided on said center and rim portion and disposed to engage the rim at a point diametrically opposite the stops at all times." Assigned to Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

BAND-BRAKE—1,735,401 for a band-brake stop for drill feed shafts on "a drilling machine or the like having a tool spindle, a sleeve on said spindle having a rack thereon, a shaft geared to said rack for rotation in timed relation to the movements of the spindle, and friction brake means for said shaft and operatively connected thereto so as to be actuated thereby at a predetermined point in the travel of the spindle to stop the movement of the spindle." Assigned to Barnes Drill Co., Rockford, Ill.

SWIVEL JOINT—1,735,637, for a swivel joint for use in the steam line of a movable pressing machine. Assigned to the Pantex Pressing Machine Inc., Pawtucket, R. I.

MAGNETIC CLUTCH—1,735,648. "In a centrifugal casting machine, in combination, means for rotatably supporting a flask or mold to be cast, a motor, and a magnetic clutch mechanism for connecting the motor to an end of the mold, said mechanism electrically controlled." Assigned to Sand Spun Patents Corp., Wilmington, Del.

ROLLING MILL—1,735,746, for a rolling mill stand having main rolls rotatable about horizontal axes, a rest bar carried by the stand at the discharge side of the main rolls and extending parallel to the axes of the latter, a carriage movable along the rest bar, a pair of vertical stub shafts carried by the carriage and each having an eccentric journal, and edging rolls journaled on the journal portions of the stub shafts. Assigned to Bethlehem Steel Co., Bethlehem, Pa.

CALENDAR OF MEETINGS

Jan. 8, 1930—Mining and Metallurgical Society of America. Meeting in New York. Percy E. Barbour, 2 Rector street, New York, is secretary.

Jan. 9—Society of Automotive Engineers. Annual dinner and election of officers in New York. Coker F. Clarkson, 29 West Thirty-ninth street, New York, is secretary.

Jan. 9-11—American Engineering council. Annual meeting in Washington. L. W. Wallace, 26 Jackson place, Washington, is secretary.

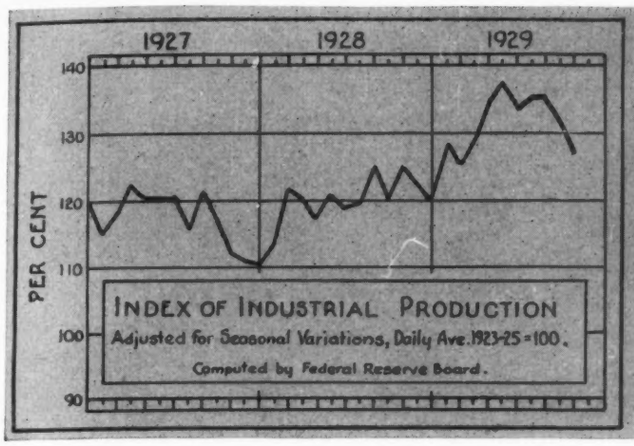
Jan. 14—Society of Automotive Engineers. Technical meeting on aeronautics at Miami, Fla. Coker F. Clarkson, 29 West Thirty-ninth street, New York, is secretary.

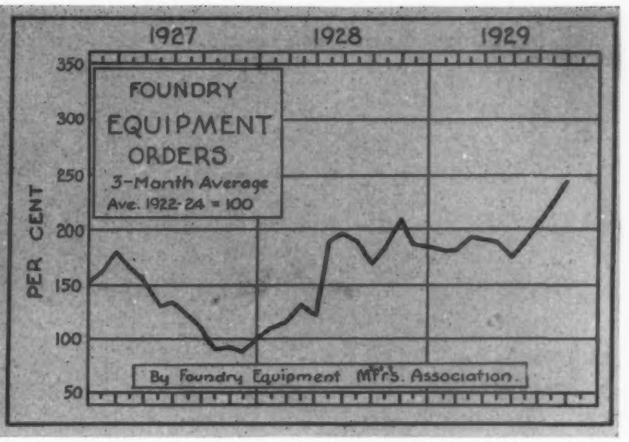
Jan. 20-24—Society of Automotive Engineers. Annual meeting at Detroit. Coker F. Clarkson, 29 West Thirty-ninth street, New York, is secretary.

Feb. 4, 1930—American Boiler Manufacturers association. Semiannual meeting in Cleveland. A. C. Baker, 801 Rockefeller building, Cleveland, is secretary.

Feb. 7-8, 1930—American Society for Steel Treating. Semiannual meeting at Hotel Pennsylvania, New York. W. H. Eisenman, 7016 Euclid avenue, Cleveland, is secretary.

May 29-31—American Electrochemical society. Spring meeting at Hotel Coronado, St. Louis. Colin G. Fink, Columbia university, is secretary.



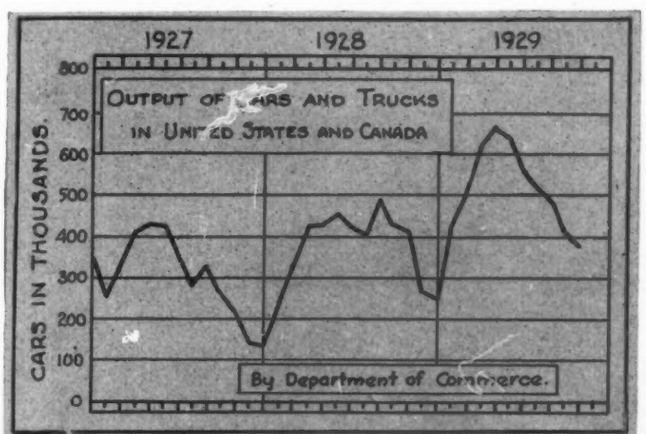


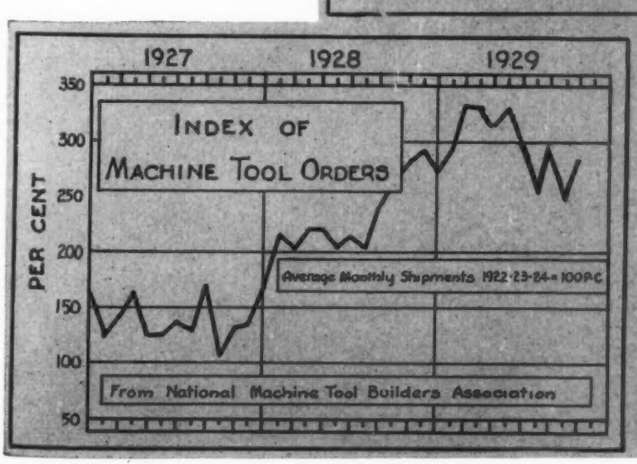
How Is Business?

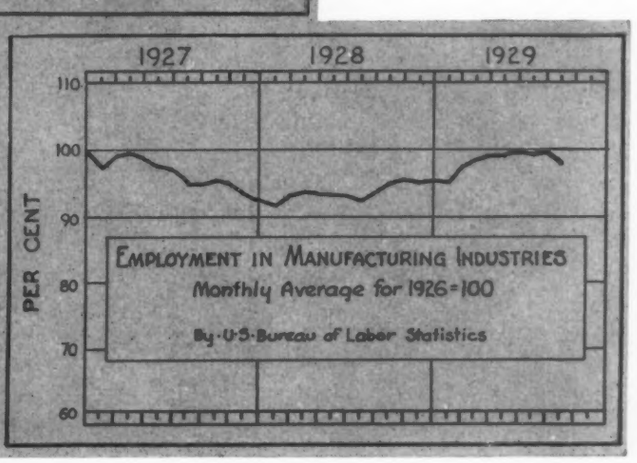
BUSINESS and financial sentiment, which was badly shaken by the recent stock market break, has witnessed some improvement as President Hoover's program for stabilizing industry takes form. Already plans for the expenditure of some $3,000,000,000 in 1930 have been announced by railroads, public utilities and industrial enterprises. Government units also will push public projects.

The significance of these developments is that they reveal a belief on the part of the country's business leaders that nothing has happened to check the rise of the long time prosperity curve of the nation. The large plans under way have been well considered and they are based upon a view of the future that is not altered by stock market fluctuations or by temporary down swings of the business cycle.

As the new year approaches, industry is moving at a distinctly slackened pace in a number of important lines. This is partly seasonal, but in the automobile trade, where the recession is most acute, there is a reflection of considerable overproduction. Output of cars and trucks for the year is estimated at approximately 5,500,000 units, with result that some oversupply exists. The curtailment now apparent in the automobile, iron and steel and a few other lines appears sufficiently pronounced to bring supply and demand into balance reasonably soon. Moreover, credit conditions are more favorable, a fact which should serve to encourage an increase in buying programs.







MEN OF MACHINES

Personal Glimpses of Engineers, Designers, and Others Whose Activities Influence Design

DIRECTORS of the Independent Pneumatic Tool Co., Chicago, recently elected Ralph S. Cooper president to fill the vacancy caused by the death of John D. Hurley, which occurred Aug. 15. Mr. Cooper was closely associated with Mr. Hurley for over 26 years. Graduated from Cornell in 1903, with a degree of mechanical engineer, Mr. Cooper immediately became affiliated with the Chicago company. In 1917 he was elected a vice president and early in 1918 was transferred to Chicago. Mr. Cooper spent 1920 and 1921 in Europe and on returning to the United States also was made general manager of all departments, in which capacity he has spent the past 8 years.

* * *

THROUGH action of the board of trustees of Cornell university, Dean D. S. Kimball, of the engineering college, has been appointed acting president of the university to take the place of President Farrand who is now abroad. Professor Kimball has been associated with Cornell since 1898 when he began his duties as assistant professor of machine design. He has been successively professor of machine design and construction, and professor of industrial engineering. Since 1920 he has been dean of the combined engineering colleges. Cornell's acting president has been president of the American Society of Mechanical Engineers, and American Engineering council.

* * *

AS A reward for his 17 years of accomplishment and reputation as a fine car designer, George H. Freers recently was appointed chief engineer of the Marmon Motor Car Co., Indianapolis. His advancement came simultaneously with the resignation of Thomas J. Litle Jr., as chief engineer. At present he is a member of the board of control of the Indiana section of the Society of Automotive Engineers. A graduate of Rose Polytechnic Institute, Terre Haute, Ind., he joined the Marmon company in 1912. In 1924 he was made assistant chief engineer. Before joining Marmon, Mr. Freers was associated with the Interstate Automobile Co., Alden-Sampson Truck Co., Packard Motor Car Co. and General Motors Corp.

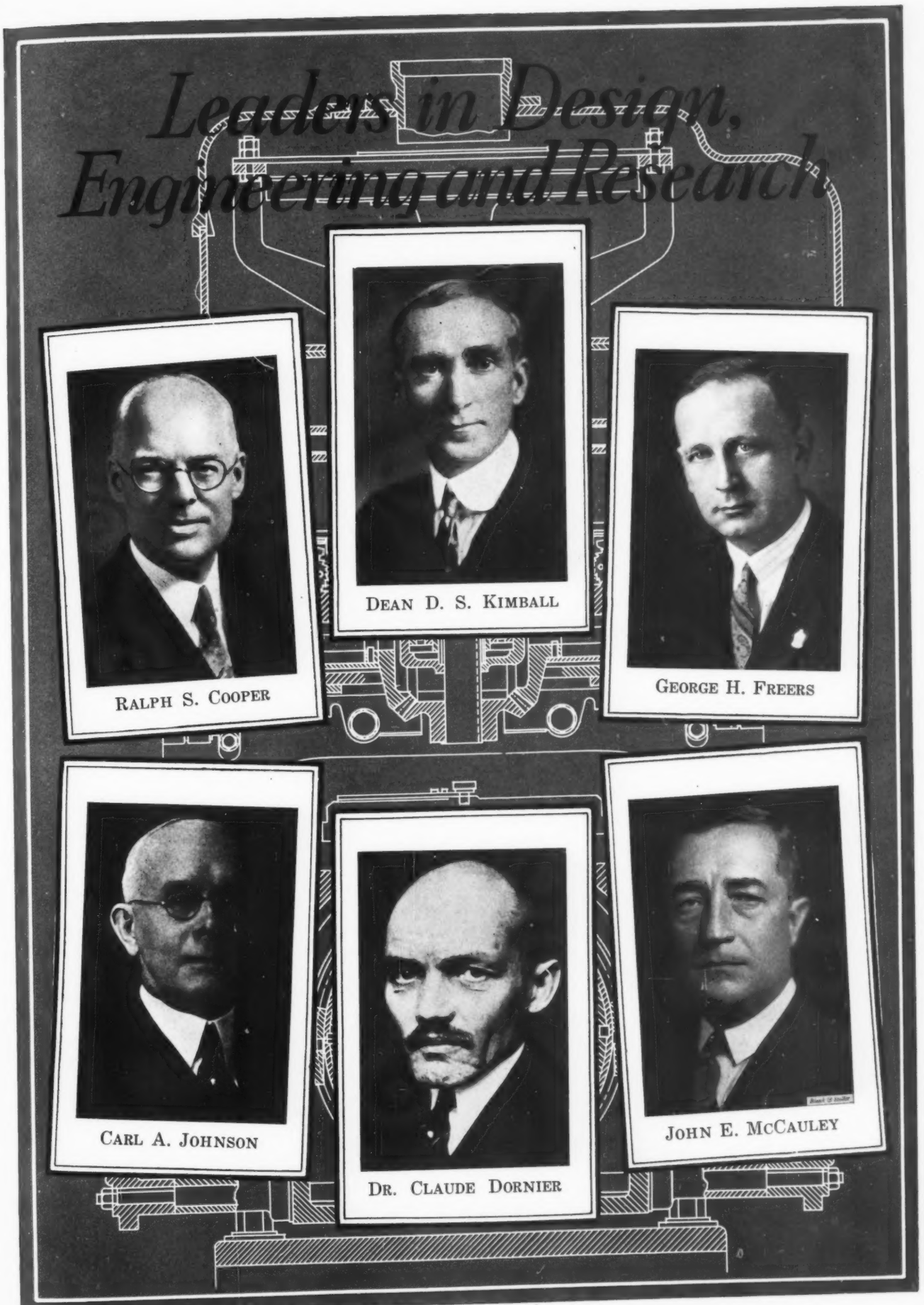
TO HEAD the National Machine Tool Builders association Carl A. Johnson, president of the Gisholt Machine Co., Madison, Wis., since 1908, was named president of that organization at the recent meeting at Briarcliff Manor, N. Y. He brings with him an experience gained through a long successful career of more than 35 years in the machine tool industry. Mr. Johnson was born at Madison, April 21, 1870, and was graduated in 1891 from the University of Wisconsin, as a mechanical engineer. In addition to his long affiliation with the Machine Tool Builders association, he is a member of the American Society of Mechanical Engineers. With his brother Hobart he was prominent in 1917 in organizing and operating the Northwestern Ordnance Co., at the request of the United States government.

* * *

NEGOTIATIONS are being made by Dr. Claude Dornier, German designer of the giant 150-passenger seaplane, DOX (Dornier X) with airplane manufacturers in this country for construction of Dornier planes in America. The successful trial flight of the 12-motor pullman of the air over Lake Constance won the German designer world wide fame. The motors of the craft are mounted on the top of the wing in two rows of six, each pair in tandem. Dr. Dornier arrived in New York recently and during his visit here will confer with officials of Fokker Aircraft Co., and the General Motors Corp.

* * *

TWENTY-FIVE years in the foundry industry is the record of John E. McCauley, recently re-elected president of the Steel Founders' Society of America. Born in Mifflintown, Pa., July 18, 1882, Mr. McCauley completed his education in the schools of that center and attended Swarthmore college and Pennsylvania state university. Before entering college, however, he served two years' apprenticeship with the Standard Steel Works, Burnham, Pa. In 1910 he entered the employ of the Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa., and later became assistant general manager, a position which he still occupies with the company. He is a member of the American Foundrymen's associa-


Leaders in Design, Engineering and Research
Dean D. S. Kimball
Ralph S. Cooper
George H. Freers
Carl A. Johnson
Dr. Claude Dornier
John E. McCauley

tion, the Iron and Steel institute, and the American Society for Testing Materials.

* * *

M. A. Smith has been appointed chief engineer of propeller activities of the Bendix Aviation Corp., Dayton, O. He recently resigned from the materials division of McCook and Wright flying fields.

* * *

J. R. Bakstad, designer of a well-known crusher, recently joined the organization of the Jeffrey Mfg. Co., Columbus, O., as manager of the sales, crusher and pulverizer divison.

* * *

R. B. Pogue has been appointed chief engineer of the American Brake Shoe & Foundry Co., New York. He has served the company in various engineering capacities and during the World war was an officer in charge of engineering for the bureau of air of the central district.

* * *

H. D. Church, recently elected vice president in charge of engineering of the White Motor Car Co., Cleveland, was in charge of all engineering of the truck department of the Packard Motor Car Co. for 10 years prior to his former association with the Chevrolet and the Hare Motor companies. In reporting this in the November issue of MACHINE DESIGN, Mr. Church's service with the Packard company was inadvertently given as 18 months.

* * *

Link-Belt Co., Indianapolis, announces the appointment of J. J. Hartley to the position of chief engineer of the company's Pershing road plant at Chicago, Ill. He was formerly in charge of foundry equipment sales in the western division of the Link-Belt organization. For the past 19 years he has held various positions with the company.

* * *

S. C. Vessy, president of the W. W. Sly Mfg. Co., Cleveland, has been elected a director of the American Foundrymen's association and D. M. Avey, editor of *Foundry*, published by the Penton Publishing Co., Cleveland, has been appointed chairman of the committee on international relations by Fred Erb, president of the organization. The vacancies were occasioned by the death of H. Cole Estep.

Mr. Vessy served once previously as director, from 1926 to 1929, and will have his headquarters in Cleveland. Mr. Avey was one of the delegates of the association to the 1929 International Foundrymen's congress in London and for years has been an active member in the association. He has served on a number of committees and at present is chairman of the committee on program and papers.

* * *

B. G. Anderson, for the past three and a half years designing and developing engineer with the Motor Starter and Air Pump Co. and its associated companies, is now connected with the Franklin Automobile Co., Syracuse, N. Y., in the engineering department.

* * *

O. E. Thaleg has joined the sales organization of Traylor Engineering & Mfg. Co. as sales engineer at the company's Chicago office. Mr. Thaleg has been associated with the sales and design of crushing machinery and plants for 20 years.

* * *

O. Wiberg, of Finspong, Sweden, and chief engineer of the Stal Turbine Co. visited this country enroute to Tokyo, Japan, where he attended the World Engineering congress as an official delegate. He presented a paper on high temperatures and pressures for steam prime movers.

* * *

Richard E. Brock has been appointed chief engineer and master mechanic of the Etna, Pa., plant of Spang, Chalfant & Co. Inc., Pittsburgh. He succeeds R. G. Connell, resigned.

* * *

J. J. Mitchell formerly Cleveland sales manager of the Square D Co., Detroit, has been placed in charge of all the company's panelboard sales, with headquarters in Detroit.

United States civil service commission announces an open competitive examination for associate mechanical engineer in internal combustion engine research. Entrance salaries range from $3200 to $3700 a year. Applications also are being received for a junior patent examiner, with entrance salary $2000 a year. Full information may be obtained from the United States civil service commission, Washington, or from the secretary of the United States civil service board of examiners at the post office or custom house in any city.

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Successful recent experience in practical application of hydro-dynamics to the design and manufacture of water pumps necessary.
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NEW MATERIALS AND PARTS

Worthy of Note by Those Engaged In the Design of Mechanisms or Machines

Develops New Roller Chain

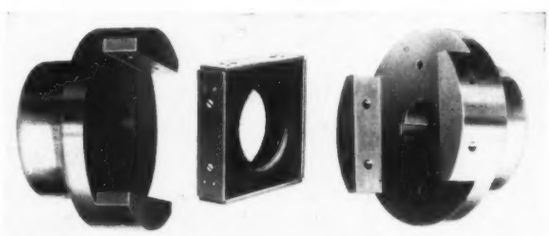
TO MEET demand for heavy, large pitch roller chain Diamond Chain & Mfg. Co., Indianapolis, has developed a new 2½-inch pitch chain as shown in the accompanying illustration.

Single strand chain with 2½-inch pitch

This chain conforms to American standards and is similar to all Diamond roller chain in design. It is made for heavy-duty applications such as large conveyors, industrial locomotives, etc. For single strand chain, the average tensile strength is 95,000 pounds. Maximum horsepower is 97 with 19 tooth sprocket, running at maximum speed of 240 revolutions per minute. The chain is made in single and multiple strands, transmission capacity and tensile strength being proportional to the number of strands.

Improved Shaft Coupling Designed

A SHAFT coupling designed as a variation of the Oldham device in which a center member is constrained to slide across the face of one coupling flange on a line passing through the

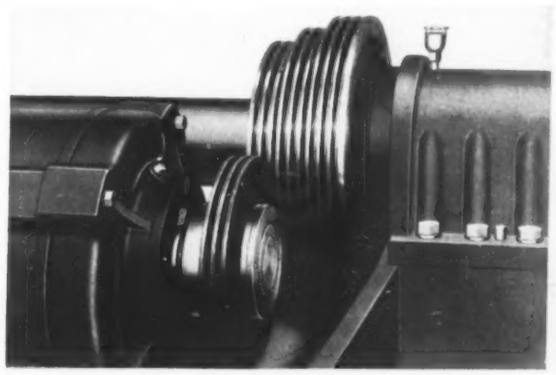


Flange sections and floating member of shaft coupling

center, and at the same time is free to slide across the face of the second flange in a direction at right angles to the first, has been announced by the American Flexible Coupling Co., Erie, Pa. The floating member of the American flexible coupling is a square, hollow casting, with a hole in the center to provide clearance for the shaft ends, as shown in the accompanying illustration. To the edges of this floating member are fastened replaceable bearing strips made from hard, tough nonmetallic compound. The flange sections are identical and interchangeable, except for the bore diameters, which are made suitable for the shafts. The flange is cast in one piece, with a wide groove machined in the face, leaving two jaws between which the floating member slides and by which the torque is transmitted.

Transmission Is V-Disk Type

EMBODIED in the construction of a new type grinder recently placed on the market by



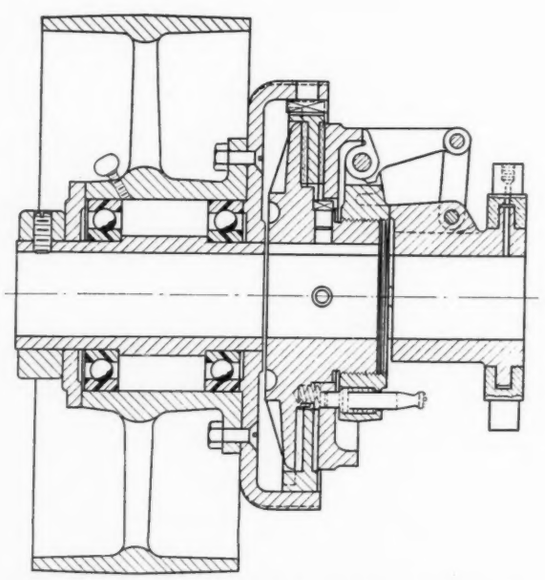
Installation of V-disk transmission on grinder

United States Electrical Tool Co., Cincinnati, is a Gibbs V-disk transmission of graphitized micarta. According to the manufacturer the grinder is the first unit of its kind to use the disk transmission. This type of unit has proved successful in many different applications, and in this installation on the grinder permits practically constant peripheral speed down to the wheel flanges. The transmission is made of ordinary micarta but impregnated with graphite,

similar to automobile timing gears. A hand lever is interlocked with the wheel guards, making it impossible to run wheels at excessive speed. On a buffer also manufactured by this company a range of from 2000 to 3000 revolutions per minute is possible with the disk transmission. The variation is accomplished by a cone or series of different size disks which revolve on a motor spindle. Any one of these, depending on the speed desired, can be quickly inserted into a stationary, metal V-disk or sheave mounted on the wheel spindle, simply by releasing the wheel cone by means of a foot pedal, and moving it into the desired position by a lever. The motor and disk cone are mounted on a rocker arm so that they may be easily moved along the mounting parallel with the wheel spindle.

Twin Disk Clutch Announced

DESIGNED for power transmission installations such as drives for pulleys or spiders carrying gears, sprockets or pulleys, the twin disk clutch announced by the Twin Disc Clutch Co., Racine, Wis., incorporates friction surfaces similar to those used in the automotive industry. The new mechanism is being distributed by the Chicago Pulley & Shafting Co., 17-23 Desplaines street, Chicago. In the accompanying illustration a cross-sectional view of the friction clutch mechanism is shown. It is balanced for speeds of 1000 revolutions per minute and is suited for heavy duty service under severe conditions. Clutch and pulley are mounted on a shaft as a unit, with the clutch body keyed to the shaft. The pulley is free to turn on the ball bearings when the clutch is not engaged. A housing attached to the pulley hub carries a friction plate and by screwing the toggle collar inward friction adjustments are made. A large pin holds this collar in place. When withdrawn and the collar rotated, the pin snaps into one of the twelve holes in the loose plate.



Sectional view, showing details of twin disk clutch

Transmission Belt Made Endless

TRANSMISSION belting of the endless cord type and known to the trade as the Goodyear Compass endless belt is being marketed by Goodyear Tire & Rubber Co., Akron, O. This product, according to the manufacturer, differs from the fabric belt, made endless with a splice, in that it has no splice in the core of cord which carries the load. The cords are embedded in rubber and are covered by an elastic, rubberized fabric envelope which takes all the surface wear. Since it is elastic all the load is properly thrown on the load-carrying cords. The belt which is shown in the accompanying illustration, is practically stretchless and extremely flexible. It is recommended by the manufacturer for drives on such equipment as air compressors, rock drills, ice machines, wood planers, spinning frames and other high-speed, small pulley drives.

Endless belt with cords embedded in rubber

Pin Nut Has Locking Features

A PIN nut with locking qualities recently was announced to the trade by Kraberhall Inc., Land Title building, Philadelphia. The new product is said to eliminate the necessity for lock washers, cotter pins, jam nuts and holes in bolts, and is considered to be entirely foolproof. The nut is placed on the bolt and after it reaches the desired position a pin is driven into one of the annular grooves cut out of the top of the nut, these grooves being tangential with the threads. This securely locks the nut. The pin is triangular and lies against the side of the groove, wedging into the thread of the bolt. To extract the pin the nut is either tightened on the bolt thereby straightening the pin for easy removal, or by using an ordinary tool such as a claw hammer.

ASSETS TO A BOOKCASE

Review of Books Pertaining to Design

A Designer's Textbook

Machine Design, by P. H. Hyland and J. B. Kommers; cloth, 448 pages, 6 x 9 inches; published by the McGraw Hill Book Co., Inc., New York, and supplied by MACHINE DESIGN for $4, plus 15 cents postage.

Primarily the purpose of the authors of this book has been to provide a textbook from which may be taught the elements of machine design. While that object undoubtedly has been achieved, Hyland and Kommers have accomplished something more—they have set down in collective form and in clear unmistakable language, much information worthy of the study of many engineers actually engaged in design work.

The book is not intended as a reference work in which may be found numerous applications of the same idea. For each general problem discussed only a few applications have been analyzed, with the thought in mind that if the fundamental principles are well understood, these principles may be applied to special problems without much difficulty.

Up-to-date knowledge of shop practice, on the part of the authors is indicated clearly here and there in the book. Processes, treatment of metals and welding are treated briefly in the second chapter, following an excellent review of the general considerations and procedure in design which is given in the first.

It is not usual to find, in earlier books on this subject, any reference to the value of combining rational and empirical methods in design. An appreciation of this, however, is shown in the opening chapter of the book, in which is explained the advantage in designing for example a press, of calculating the strength of the frame and the sizes of shafting and gears, and then comparing these with those of other successful machines performing somewhat similar work.

The subject of kinematics has been treated as an integral part of machine design. A chapter is included on linkwork, instant centers and velocity diagrams, followed by another on cam design.

Under the heading materials of construction the authors deal with materials used in design in the order of their importance: iron in its forms of cast iron, steel, malleable and wrought iron; copper and alloys of copper, brass and bronze; aluminum alloys; babbitt metals; and materials such as wood, fiber, leather and mica. Contents and properties of the materials are given in many cases.

Interesting chapters on fundamental mechanics, riveted fastenings, power screws, keys and couplings, shafting, gears, clutches and lubrication, design of machine elements such as springs, flywheels, cylinders, plates and columns; machine frames and safety engineering, serve to make up a work which is deserving of a welcome reception by the design profession.

* * *

Auto and Tractor Design

Motor Vehicles and Tractors, by P. M. Heldt; cloth, 678 pages, 6 x 9 inches; published by P. M. Heldt, Nyack, N. Y., and supplied by MACHINE DESIGN for $8, plus 15 cents postage.

All elements of the automobile and tractor except the engine and electrical equipment are covered in this textbook on design. While the book is intended to supplant the former second volume of the author's *Gasoline Automobile*, and repeats some of that material, it is essentially a new work. Only simple mathematics are used and much practical information is disseminated. The volume is suitable for class or home study.

Danly Machine Specialties Co., 2104 South Fifty-second avenue, Chicago, has been appointed by the Kinite Corp., Milwaukee, as representatives for the Chicago district, which includes Illinois, Missouri, upper Indiana, and Iowa. The Danly company will handle the sales of Kinite cast-to-shape machine parts and dies as well as Kinite bar stock.

The St. Louis district sales office of Cutler-Hammer Inc. has been moved from 611 Oliver street to 1914 Washington avenue, St. Louis. A warehouse has been established adjoining the sales office to carry a stock of standard C-H motor control and wiring devices for immediate delivery.

L. A. Benson & Co., Baltimore, have been appointed distributors for Diamond roller chain to the industrial trade in that territory, by Diamond Chain & Mfg. Co., Indianapolis.

TOPICS OF THE MONTH

A Digest of Recent Happenings of Direct Interest to the Design Profession

BRIEF cables received from Tokyo indicate that the World Engineering Congress held recently in that Japanese city more than fulfilled expectations in every respect. It is reasonable to expect that when full reports are available, much of interest to machine design will be found. American visitors were impressed with the remarkable engineering achievements of their hosts, and it is likely that more and more ideas emanating from the Orient will find application in the Western world.

* * *

Approve Code for Textile Machinery

Approval as an American tentative standard of a new safety code for textile machinery recently was authorized by the American Standards association.

* * *

Names Robot Airplane Pilot

"Mecaviator" is the name given to the automatic robot which recently piloted an army airplane from Wright field to Bolling field. The name is a shortened combination of "mechanical aviator."

* * *

Discuss Power Equipment in Hotel

The Nov. 26 issue of *Power* is devoted to a single theme "The Power Devices Everywhere," as exemplified in the New Yorker hotel. Details of the power equipment for the hotel's heating, elevator, lighting, refrigerating, cleaning, water and other services are described.

* * *

Propose Practice for Drawings

The American Society of Mechanical Engineers and the Society for the Promotion of Engineering Education are jointly sponsoring a proposed standard practice for mechanical drawings through the American Standards association.

* * *

Reports Cageless Bearing from Germany

The September issue of *The Automobile Engineer* contains the report of a ball bearing designed in Germany in which the usual cage is replaced by a third row of small balls located above and between the two rows of bearing balls. These serve to keep the main bearing balls from touching one another. The small distancing balls are held by a grooved ring which floats inside the body of the bearing. Thus the unit is in reality a cageless bearing.

* * *

World's Largest Land Plane

The world's largest land plane is now ready for initial examination before being launched on its trial flight, according to an announcement issued by the Junkers plant at Dessau, Germany. It is an all-metal craft and has four motors with a total of 2400 horsepower. They are installed inside the wings, which have enough space at the tips for a man to stand erect. Berths will accommodate 40 passengers.

* * *

Will Steam Motor Car Gain Favor?

An editorial in the December issue of *Mechanical Engineering* calls attention to the fact that the steam motor car, which is rarely seen in America is common in Europe, and particularly so in England. After reviewing factors favorable to the steam vehicle abroad and those unfavorable to its widespread use in this country, the editorial writer concludes that "if successful at all, the development of the steam car (in America) will be the result not so much of some new invention as of the application to the problem of road vehicles of those principles of design and operation which have been so highly developed in central station and locomotive practice."

* * *

Use "Electric Eye" for Traffic Control

Use of the photo-electric cell in a system of automatic traffic control was demonstrated at the National Electrical exposition held recently in New York. The system, invented by Dr. Phillips Thomas of the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., is based on the use of photo-electric cells. These are buried in the road and covered by a glass bullseye at a place where a vehicle waiting for a traffic light to change, would stop. In event the photo-electric cell becomes inoperative, the traffic signals will work as usual, opening the intersecting highways alternately. The new system can be applied to any of the present systems of traffic control by luminous signals.

Every *designer should have* this booklet

Booklet 104 "Simplifying and Improving Machine Design"

IN practically every industry . . . woodworking, textile, canning, baking, bottling, packing, printing, etc. . . . there are machines which have been simplified, improved and given added salability through the use of Diamond Chain. This 40-page Booklet 104 presents this dependable drive as applied to machinery. It is plentifully illustrated and will suggest many possible improvements to men responsible for design.

Ideas for Any Manufacturer

One of these applications alone may point the way to a saving in costs or may help solve a main or interpart drive that has been bothering you.

Rolling at every point of contact Diamond Chain provides the utmost in smoothness of operation and at the same time insures 100% positive drive at 98-99% efficiency.

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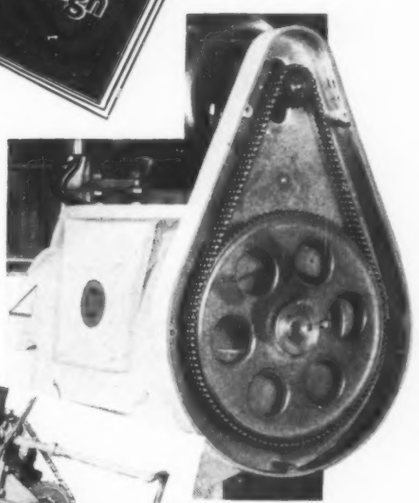
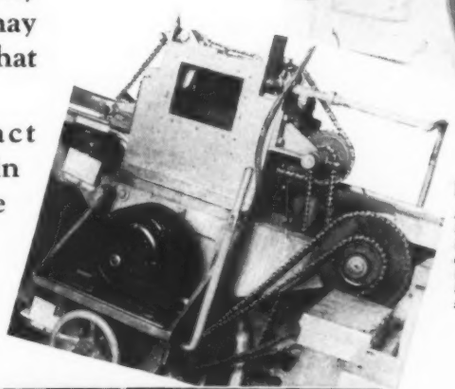
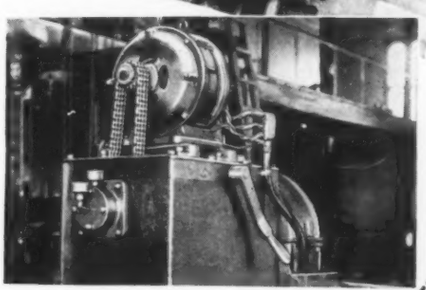


CAKE MIXER
Diamond Double Roller Chain displaced a so-called "silent" chain on this Cake Mixer because it proved to be a more quiet and more efficient transmission.



PINEAPPLE SLICER
Another interesting application of Diamond Chain is on this Hapco Automatic Pineapple Slicer. The drive for this machine must be extremely flexible as well as acid-resisting.



LATHE
"This drive is giving good service", says the General Engineering & Mfg. Co., St. Louis, who drive this 36" lathe through Diamond Chain from an 1800 R. P. M. Motor.

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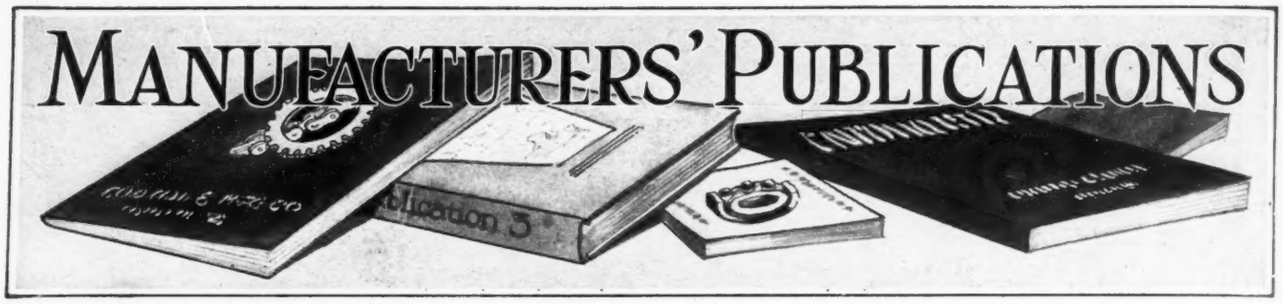


ELECTRIC CONTROLLERS—Allen-Bradley Co., Milwaukee, manufacturer of electric controlling devices, has prepared a loose-leaf catalog of its products. A chapter is devoted to the mechanical and electrical departments as well as to the research, sales and service divisions. The catalog is well indexed and copiously illustrated. Direct-current, manual and automatic starters, mill and crane controllers, rheostats and battery charging and testing equipment are described.

ISOLATION—Korfund Co. Inc., New York, has issued the first of a regular publication on scientific, practical and economical application and study of materials and methods of deadening and eliminating machine vibration and noise. A special pneumatic hammer foundation is described. It will be published quarterly for all who are interested in this subject.

GEARS—Westinghouse Electric & Mfg. Co., Pittsburgh, has prepared a bulletin on its heat treated and hardened gears. It gives facts about these gears and their uses and contains a tabulation of physical properties and numerous kinds of gears and curves showing relative hardness of gear teeth at various depths.

PUMPS—Bulletins on three types of its pumps have been issued by the Economy Pumping Machinery Co., Chicago. One covers its horizontal and vertical non-clogging centrifugal pump, a second its small multistage centrifugal pump and the third its nonclogging sump pumps. They are illustrated in detail to show construction and operation. A head capacity table and data are given, with drawings.

STEEL CASTINGS—Lebanon Steel Foundry, Lebanon, Pa., describes in a current bulletin the use of its electric steel castings for rugged use, such as in transmission cases of trucks designed for heavy duty.

ARC WELDING—Lincoln Electric Co., Cleveland, in the current issue of its series on studies in structural arc welding, presents comparisons between riveted and arc welded plate girders. Drawings and data are included.

STEEL CASTINGS—Nugent Steel Castings Co., Chicago, devotes a current bulletin to a description of how a tractor builder solved a problem by use of steel castings for spade lugs on his tractors.

GRAPHIC INSTRUMENTS—Continuous inspection by means of graphic instruments is illustrated in a bulletin by the Esterline-Angus Co., Indianapolis. Use of instruments manufactured by this company in inspecting air-brake operation is described and the results illustrated.

ALLOY STEELS—A handbook of special alloy steels has been published by Edgar Allen & Co. Ltd., Sheffield, Eng. It describes a large range of steels for various purposes with illustrations of forms in which each is used.

COMMUTATORS—Ideal Commutator Dresser Co., Sycamore, Ill., has issued a booklet which really is a commutator maintenance encyclopedia. It has a chapter on operation of direct-current generators, definitions of electrical terms, tables on carrying capacity of solid and stranded wires, tables of fusing, wiring and full load data and other features. It is illustrated.

LUBRICATION—Texas Co., New York, discusses lubrication in the presence of water in a current issue of its publication devoted to lubrication. It is illustrated to show methods in use in various machines including steel mill equipment, pumping machinery and hydraulic equipment.

CENTRIFUGAL PUMPS—Duriron Co. Inc., Dayton, O., describes in a current bulletin two types of its centrifugal pumps, designed for use where materials to be pumped are corrosive and destructive to ordinary materials. It is illustrated and charts show ratings of various models.

VALVES—Foster Engineering Co., Newark, N. J., recently issued catalog No. 60 in which it describes its valves, pump governors and pressure regulators.

MOTORS—Elliott Co., Jeanette, Pa., is distributing its bulletin L-3 on Elliott Type A-1 synchronous motors for compressor drives.

COUPLINGS—Data charts, installation and lubrication information are contained in bulletin No. 4 on flexible couplings, which was recently issued by the American Flexible Coupling Co., Erie, Pa.

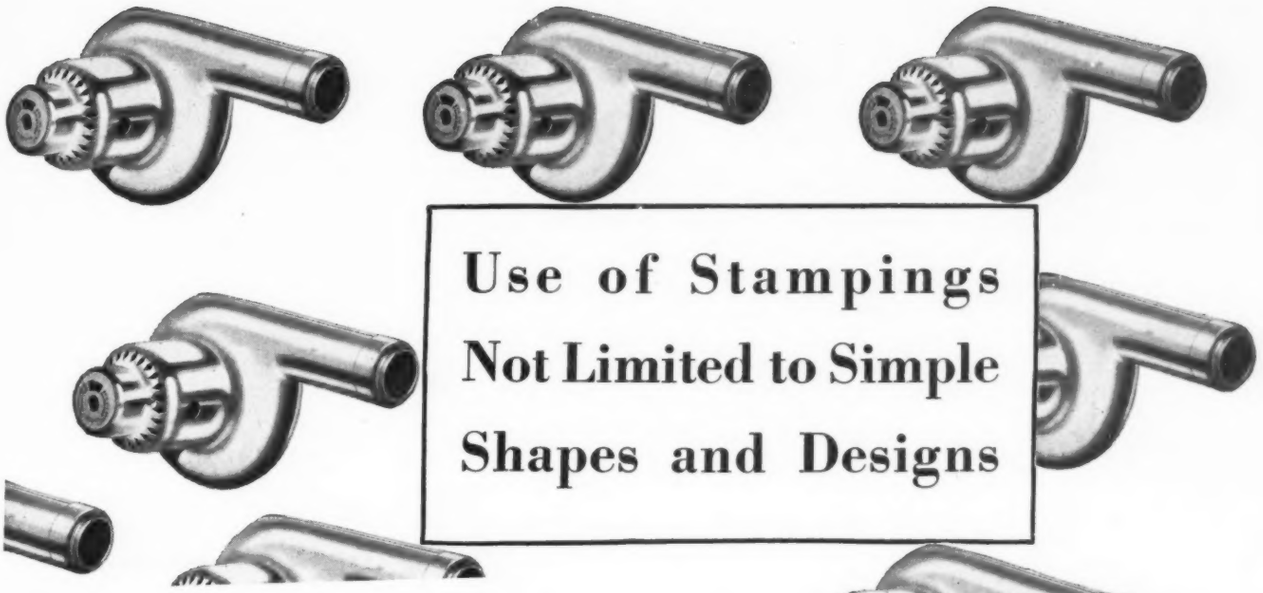
OILING DEVICES—William W. Nugent & Co., 410 North Hermitage avenue, Chicago, has issued a second edition of bulletin No. 15 on oiling and filtering systems, oiling devices and accessories.

STEEL CASTINGS—Sivyer Steel Casting Co., Milwaukee, recently issued a 4-page illustrated leaflet which propounds "Fewer Dollars; Lower Inventories; Sivyer Castings." Data on physical properties of a heavy duty drive pinion of chrome-alloy steel are given.

CORROSION-RESISTANT ALLOYS — "Meeting the Metal Requirements of the Process Industries," is the title of a 16-page pamphlet issued by the International Nickel Co., New York. Corrosion data are given for a number of corrosion resistant alloys into which nickel enters, and the different equipment in which they are used. Illustrations show the applications pictorially and a table also is given showing uses of monel and nickel to overcome corrosive action.

CONDULETS, GROUNDULETS—A bound catalog containing 280 pages issued by the Crouse-Hinds Co., Syracuse, N. Y., illustrates its line of condulets, groundulets, plugs and receptacles. This supersedes all previous listings and is cross indexed to give ready access to a wide variety of items.

RARE METALS—Fansteel Products Co. Inc., North Chicago, Ill., has issued an attractive 55-page booklet on the history, properties and uses of tantalum, tungsten and molybdenum. Tables are printed giving data on technical characteristics of the three metals as well as

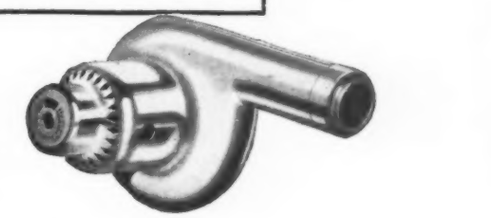


Use of Stampings Not Limited to Simple Shapes and Designs

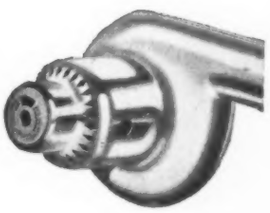
SWIFT progress is being made in the successful adaptation of pressed metal to products of intricate shape and design. One after another, manufacturers using castings, forgings, wood and similar parts in odd shaped products, are switching to the use of pressed metal—radically lowering production costs and at the same time improving the appearance and salability of their products.

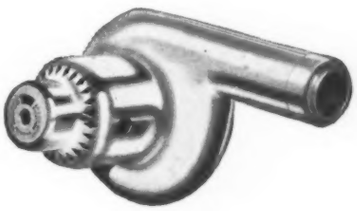
Through constant research, backed by 50 years' experience in pressed metal work, G. P. & F. engineers are finding ways to produce intricate products more economically for hundreds of manufacturers. In die making, too, G. P. & F. experience counts, both in original cost and quality of stampings. And the 15-acre G. P. & F. plant, with ultra modern equipment and 1500 skilled workmen, is assurance of economical production and profit deliveries. Likewise, enormous raw material purchases guarantee low prices.

Submitting your present product, or blue prints of new ones contemplated, entails no obligation on your part. G. P. & F. engineers will gladly offer recommendations and quote prices.



This electric hair dryer case is an example of intricate shape and design. With such a product stampings were essential, because anything but stampings would have made the product too heavy to be practical.





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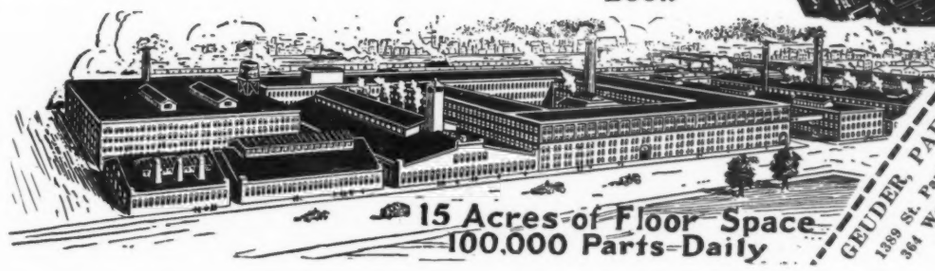

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on platinum, copper and nickel. Other data presented include electrical resistance of molybdenum wire in ohms per 1000 feet, sheet and bar data—weights per unit area, wire data, and corrosion resistance of tantalum.

DIE CASTINGS—Descriptions and illustrations of a wide variety of parts die cast from zinc base alloys make up the contents of an interesting booklet being distributed by the New Jersey Zinc Co., 160 Front street, New York. The annual consumption of this alloy has increased from 6000 tons in 1921 to over 30,000 tons at the present time. Another booklet dealing more extensively with die castings made of Horse Head zinc alloys now is in the course of preparation by the New Jersey company and soon will be ready for distribution.

PIPE—Youngstown Sheet & Tube Co., Youngstown, O., is distributing a folder on facts about pipe it manufactures. Besides tables, giving data on dimensions and prices, the folder discusses briefly the importance of pipe couplings.

ELECTRIC CONTROL—A 4-page bulletin No. 740 issued by Allen-Bradley Co., Milwaukee, describes a starting device for squirrel-cage motors.

MOTORS—General Electric Co., Schenectady, N. Y., is distributing its bulletin 151-B containing 64 pages. It lists motors manufactured by this company for driving main rolls of rolling mills to a total of 767 units, rated at 1,105,490 horsepower. Classification is made according to the type of mill and drive, and illustrations show typical installations.

FLEXIBLE COUPLINGS—Bulletin 168-A issued by T. B. Wood's Sons Co., Chambersburg, Pa., contains data on that company's line of universal Giant flexible couplings.

ELECTRIC HEAT—Commonwealth Edison Co., Chicago, Melting of various kinds of metal, annealing, galvanizing, has issued a booklet on electricity for industrial heating. rivet heating, enameling and cleaning by electric heat are shown by typical illustrations.

PRESSED STEEL—Youngstown Pressed Steel Co., Warren, O., is distributing two booklets, "Adventures in Redesign," and "Feet Can Be Saved." The first booklet of 24 pages covers the work the company is doing in redeveloping and redesigning parts into pressed steel. The other, a 16-page publication, describes a line of steel material handling equipment.

PUMPS—Goulds Pumps Inc., Seneca Falls, N. Y., in a current bulletin calls attention to the scope of its service in designing installations for industrial or power plant pumping.

PUMPS—Chicago Pump Co., Chicago, has issued a catalog of its products, 200 pages, describing its pumps, their application, engineering tables, specifications and a special section of useful information. It supplies much information pertaining to modern buildings and pumping equipment used therein.

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MACHINE DESIGN is a monthly technical publication conceived, edited and directed expressly for those executives and engineers responsible for the creation and improvement of machines built for sale, and for the selection of the materials and parts to be used.

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MACHINE DESIGN

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